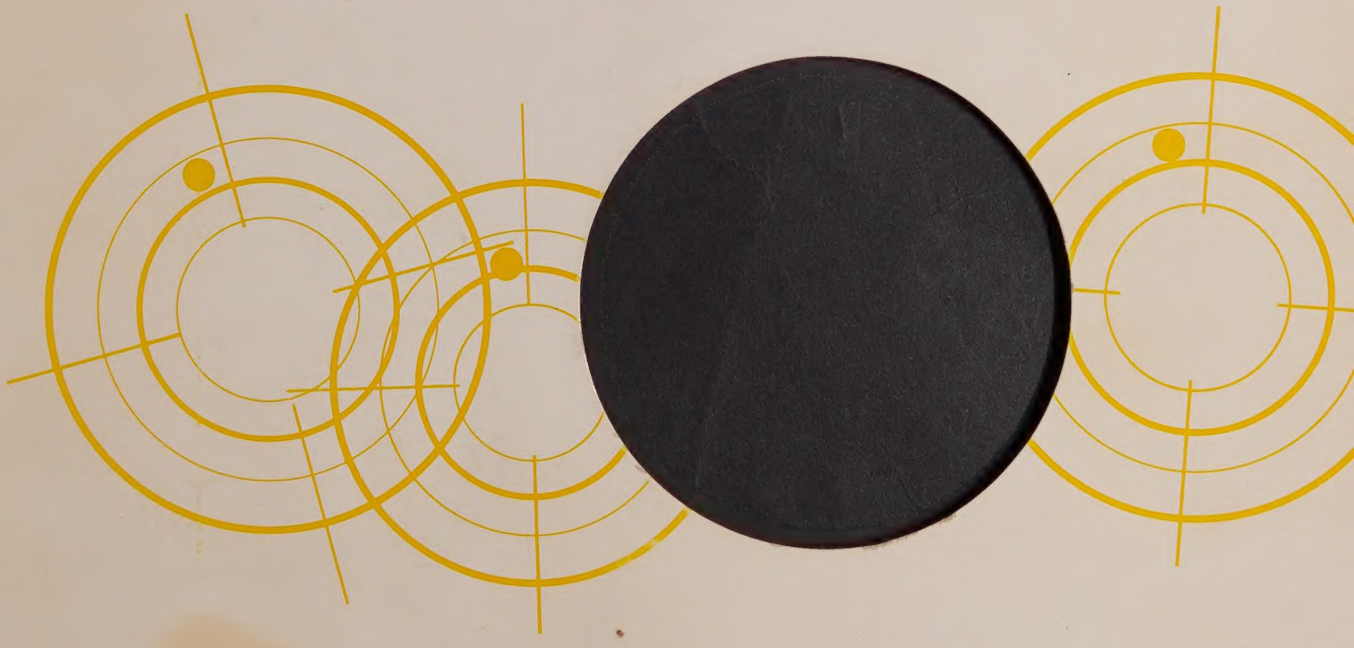
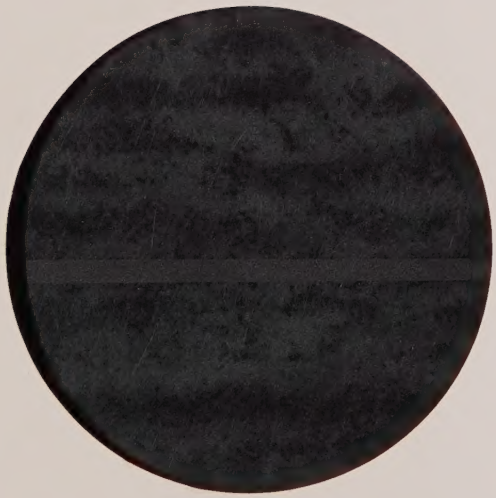
REMANCO





REMANCO

Instruction Manual

SERVODYNE

MODELS:
902D
902DK
902DSG
903A

1805 COLORADO AVENUE • SANTA MONICA, CALIFORNIA

SERVODYNE

MODELS: 902D
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INSTRUCTION MANUAL

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INSTRUCTION MANUAL

MODELS 902D, 902DK, 902DSG, 903A

SERVODYNE

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Appendix A

SERVODYNE

MODELS 902D, 902DK, 902DSG, 903A

1.0 GENERAL DESCRIPTION

The SERVODYNES, shown in figure 1-1 and 1-2, are all-electronic servo test sets designed for the general purpose testing of AC and DC servo systems. They enable the operator to completely evaluate AC systems, and to perform measurements of frequency, phase, and transient response characteristics of DC systems. The units contain a precision function generator with a frequency range of 0.001 to 990 CPS, depending on the model, and the precision phase shifter with direct reading dial which permits phase measurements to an accuracy of plus or minus one degree. Additional circuits within the test sets support their capability to provide the following:

1. Sinusoidal, squarewave and peak reference outputs over the entire frequency range.

2. Triangle and trapezoidal outputs over the entire frequency range with an SF-1 or SF-2 module included.

3. Modulated carrier output with all above waveforms.

4. Modulated and unmodulated phase shift (0-360^{o}) (Modulation only if SF-1 or SF-3 is included).

5. Synchronized linear sweep of approximately 20V amplitude.

The SERVODYNE is designed to provide an internal carrier signal for exciting the line phase of two-phase motors. It can also utilize an external carrier at any frequency from 45 to 5000 CPS. The specific internal carrier frequencies are determined by the plug-in module in use.

The SERVODYNE is a self-contained unit, furnished in a metal cabinet, with provisions for rack mounting. A blower, located on the main chassis, maintains a flow of coolant air within the cabinet.

All operating controls and indicators are located on the front panel. Adjustment controls are principally accessible from the top or front of the equipment.

Modular design has been employed in the interest of rapid servicing. Each module may be tested external to the equipment with the aid of the interrupter cable supplied with the test set.

The SERVODYNE utilizes only electronic circuits in accomplishing its function. The lack of mechanical devices makes possible the attainment of the highest degree of stability and long term reliability. Maintenance is simple and straightforward, since standard electronic components are used throughout the equipment.

The test set is supplied with the required power cable. Connector and cap are supplied for the carrier output, so that cables complying with user requirements can be fabricated by the user. A standard power cable may be used for external carrier input.

Figure 1-1. SERVODYNE Test Set (Model 903A)

Figure 1-2. The SERVODYNE Test Set (Model 902D)

2.0 SPECIFICATIONS

2.1 Model 902D (Digital)

Frequency	.01 to 99 cps in three decades. Extendable to .001 CPS with EF-1 Module.
Frequency Accuracy	± 2% of reading.
Frequency Stability	± .015% for eight hour period.
Output Amplitude	0-30 volts peak to peak at 8 MA peak current, with 0.1V resolution read on helidial. 0-3V peak to peak with 0.01 volt resolution.
Output Amplitude Accuracy	± 2% of full scale or ± 3% of reading whichever is less. This applies to the signal outputs when using the internal carrier. When using an external carrier, the output amplitude accuracy will be maintained if the unit is adjusted with the particular external carrier level being used.
Modulated Signal Output	Sine wave, square wave, peak reference, triangle and trapezoid. (See note 1.)
Modulator Distortion	Less than 3% for signal output of greater than 10% of peak level.

Internal Carrier Frequency	60 and 400 CPS with ± 5 CPS deviation control for 60 CPS; ± 30 CPS for 400 CPS.
External Carrier Requirements	115V RMS, ± 20% 1 Watt, 45 to 5000 CPS.
Internal Carrier Output (with PR-64 Module)	16 watts, 115 volts or 26 volts RMS.
Square Wave Rise & Fall Time	100 microseconds maximum.
Synchronized Linear Sweep (Approx. 20 volt amplitude)	Permits viewing of 1 full cycle of the output over full frequency range.
Phase Shift Output	Approximately 80 volt peak-to-peak signal. 0 to 360 degrees variable phase shift with respect to output signal. Minimum load 100K ohms.
Phase Measurement Accuracy	± 1 degree.
Methods of Phase Measurement (Direct Reading Dial)	1. Vary phase of sweep with respect to output signal. 2. Compare measured signal with phase shift output by 0 degree Lissajous pattern.
Power Supply	115/230 ± 10/20 volts, 50-60 CPS.
Power Consumption	(115/230 volts, 50/60 CPS) Without internal carrier module: approximately 375 watts With internal carrier module: approximately 450 watts.
Size	12 1/4" x 19" x 17" (rack mountable).

Weight (With Internal Carrier Module)	Approximately 75 lbs.

NOTE:

(1) Triangle and Trapezoid only if SF-1 or SF-2 module included.

2.2 Model 902DK (Digital)

Frequency Range	.1 to 990 cps in three decade steps. Extendable to .01 cps with EF-1 Module.
Phase Measurement Accuracy	$\pm$ 1° up to 99 cps. $\pm$ 2°, 100 to 990 cps.
Other Specifications	Same as 902D

2.3 Model 902DSG (Digital)

Signal Ground	The signal ground is isolated from the chassis ground.
Phase Shift Output	Approximately 80 volts. Peak-to-peak into 10K ohm load.
Phase Output Tracking	The fundamental frequency content of the phase output tracks the signal output within $\pm$ 1%.
Rear Connectors	All front panel signals are also brought to Bendix Pygmy connectors on rear of cabinet.
Other Specifications	Same as 902D.

2.4 Accessory Specifications

2.4.1	Internal Carrier Module	PR-64
	Carrier Frequency	60 and 400 CPS.
	Power Output	16 watts.
	Voltage Outputs	115 volts RMS and 26 volts RMS.
	Voltage Regulation	115 volts: ±0.5% line & load. 26 volts : ±0.5% line only.
	Carrier Phase	115V and 26V are 90° (std) or 0° (optional) with respect to modulated signal. Selection by simple wiring change.
2.4.2	Plug-in Carrier Kit	P-XXX Accessory plug-in kits permit the SERVODYNE to be operated at customer specified carrier frequency in place of the standard 60/400 cps.
2.4.3	Extended Frequency Module	EF-1
	902D Frequency Extension	From: 0.01 - 99 cps to: 0.001 - 99 cps.
	902DK Frequency Extension	From: 0.1 - 990 cps To: 0.01 - 990 cps.
	902DSG Frequency Extension	From: 0.01 - 99 cps To: 0.001 - 99 cps.
	903A Frequency Extension	From: 0.1 - 100 cps To: 0.01 - 100 cps

2.4.4	Special Function Module	SF-1
	a. Special Functions	Triangle & Trapezoid.
	b. Phase Shift Output	Carrier modulated phase shift output available for bow tie patterns with demodulated feedback signals. Spoke type Lissajous patterns with modulated feedback signals.
2.4.5	Special Function Module	SF-2
	Special Functions	Triangle Trapezoid
2.4.6	Special Function Module	SF-3
	Phase Shift Output	Carrier modulated phase shift output available for bow tie patterns with demodulated feedback signals. Spoke type Lissajous patterns with modulated feedback signals.
2.4.7	Analog Converter	AC-3
		Servodyne models 903A and 902D are both compatible with Analog Converter AC-3. When used with the AC-3, analogs of frequency, phase, and system gain are developed for use with standard recorders.

3.0 OPERATING INSTRUCTIONS

NOTE:

IF SPECIAL FUNCTION MODULE SF- IS ADDED TO THE SERVODYNE BY THE CUSTOMER, A JUMPER SHOULD BE CONNECTED BETWEEN STANDOFF TERMINALS E1 and E2 IN POWER SUPPLY 1A4.

These terminals are located adjacent to V4 tube socket. Adding this jumper will insure proper plate dissipation in V4.

3.1 Preparation for Use

Prior to initial use, performance of Preliminary Functional Check, paragraph 3.3, is recommended to demonstrate normal operation of the instrument. The time recommended for warm-up and stabilization of the equipment is 15 minutes. In normal use, no preliminary procedures are required.

3.2 Operating Controls

(See figure 3-1 for 903A, figure 3-2 for digital models.)

3.2.1 POWER (Lower Left Front Panel)

3.2.1.1 FIL ON-FIL OFF

This switch controls the application of power to the filament circuits throughout the test set. The indicator lights when the filaments are energized. The fuse holder accommodates the 4-amp slo-blo fuse required.

NOTE:

For 230V AC operation, a 2-amp slo-blo fuse is used.

3.2.1.2 B+ ON/OFF

This switch controls the application of B + power throughout the test set, and serves as a standby switch. The indicator lights when the B + circuits are energized. The fuse holder accommodates the 3-amp slo-blo fuse required.

NOTE:

For 230V AC operation, a 1.5-amp slo-blo fuse is used.

3.2.2 SIGNAL

3.2.2.1 AMPLITUDE (VOLTS P-P)

This control drives a precision potentiometer which determines the peak-to-peak amplitude of the output signal. The helidial permits direct reading of this voltage in units and tenths. For example, a dial reading of 295 indicates 29.5V peak-to-peak with the upper switch at x 1.0, or 2.95V peak-to-peak with the upper switch at x .1.

3.2.2.2 PHASE SHIFT (DEG)

The phase shift control provides continuous selection of from 0 to 360 degrees phase shift in the sweep signal with respect to the output signal. The number of degrees of phase shift may be read directly from the dial. A reference sinusoidal signal, in phase with the sweep, is also provided at a front panel terminal post.

3.2.2.3 ZERO ADJ.

This front panel adjustment is used to set the DC level of the output signal to 0 volts.

3.2.2.4 WAVEFORM

This switch permits the selection of a sine, square, peak reference, triangle or trapezoidal output signal from the SERVODYNE. (Triangle & Trapezoid only with SF-1 or SF-2)

3.2.2.5 FREQUENCY (CPS)

MODEL 903A

The frequency control provides for continuously variable selection of the operating frequency within the range established by the RANGE switch. The dial indication, when multiplied by the factor shown at the appropriate RANGE switch position, yields the operating frequency in cycles per second.

MODELS 902D, 902DK, 902DSG

Nixie readout is provided along with automatic placement of the decimal point. The frequency is varied by turning the FREQUENCY (CPS) dials.

3.2.2.6 RANGE

This control selects the frequency range containing the desired operating frequency. On the 903A it indicates the multiplier to be used in conjunction with the frequency dial reading; on the 902D the decimal is automatically placed.

3.2.2.7 START

This control provides a means of starting or resetting the low-frequency oscillator. It is used principally when the SERVODYNE is set up for operation at the lower frequencies, and avoids the delay which sometimes occurs before oscillations start in these ranges.

3.2.3 CARRIER (Lower Center Front Panel)

3.2.3.1 CARRIER CPS

The CARRIER CPS switch permits the use of the 60 CPS

3.2.3.1 CARRIER CPS (cont'd)

or 400 CPS carrier signals supplied by the PR-64 module, or selection of an externally supplied carrier which can be connected to the unit by means of a rear panel connection.

NOTE:

Other carrier frequencies can be made available internally through the use of other carrier plug-ins. These are furnished to fit special requirements at a nominal additional cost.

3.2.3.2 DEVIATION (CPS)

This control permits continuously variable deviation from the specified internal carrier frequency. The limits of deviation are approximately ±5 CPS for 60 CPS and ±30 CPS for 400 CPS.

3.2.4 OUTPUT (Lower Right Front Panel)

3.2.4.1 UNMOD-MOD

This switch permits selection of either the unmodulated function generator output or the modulated carrier output as supplied to the SIGNAL terminal.

3.2.4.2 Y AXIS SIGNAL-EXT SIG

This switch permits selection of the signal connected to the Y AXIS terminal. In the SIGNAL position, the SERVODYNE output signal is provided to Y AXIS terminal. In the EXT SIG position, an electrical connection is made from Y AXIS terminal to the EXT SIG terminal. Normally the output of the servo system under test is connected to the EXT SIG terminal.

3.2.4.3 SWEEP

This terminal supplies the linear (sawtooth) sweep output of the SERVODYNE, for connection to the X axis of an oscilloscope.

3.2.4.4 SLOPE (TRAPEZOID)

The SLOPE control varies the slope of the trapezoid when Special Function Modules SF-1 or SF-2 are used. The slope may be varied from approximately a triangle to square wave. This allows varying the velocity of servo systems and is often more useful than the triangle or square wave in studying the system response.

3.2.4.5 PHASE SHIFT

The upper terminal supplies an unmodulated sinusoidal signal in phase with the sweep signal, for connection to the X axis of an oscilloscope when a sinusoidal sweep is desired. In addition, with the SF-1 or SF-3 included, the terminal signal at the lower (MOD) will be modulated to allow phase on an AC system to be measured using a Lissajous pattern.

3.2.4.6 SIGNAL

This terminal supplies the output signal from the SERVODYNE.

3.2.4.7 EXT SIGNAL

This terminal provides a convenient connection for the output of the servo system under test, to be switched internally to the Y axis input of an oscilloscope.

3.2.4.8 Y AXIS

This terminal is used for connection to the Y axis of an oscilloscope. The signal provided is selected by means of the Y AXIS switch to be either the output signal of the SERVODYNE or the output signal of the servo system under test.

3.3 Preliminary Functional Check

The operator may use the procedure in the following paragraphs to become familiar with operation of the SERVODYNE before making any adjustments or performing a system test.

3.3.1 Provide connections to rear panel connectors as follows (see figure 3-3).

NOTE:

If equipment is to be used with 230V AC power, it is first necessary to rearrange the jumpers on terminal board TB3 as shown on chassis wiring diagram 1. The fuses must also be changed as described in para. 3.2.1.

a. POWER INPUT to 115V AC source.

b. EXT. CARRIER INPUT to 115V AC external carrier supply (or 115V AC line for this test).

3.3.2 Perform functional check as follows:

a. Set filament switch to FIL ON and allow equipment to warm up.

NOTE:

Warm-up time prior to turning B+ on depends upon intended use. Tube life will be improved by allowing 30 seconds. For calibration adjustments or best accuracy, 15 minutes is recommended.

b. Set B+ switch to B+ ON and set front panel controls as follows:

1. PHASE SHIFT dial to 0 degrees.

2. WAVEFORM to SINE

3. UNMOD-MOD switch to UNMOD

4. RANGE switch to:
   D for digital models
   X10 for 903A

5. FREQUENCY to:
   90. for 902D, 902DSG (nixies)
   900. for 902DK (nixies)
   9 for 903A (dial)

6. CARRIER CPS switch to EXT

3.3.2 Perform functional check as follows: (cont'd)

b. (cont'd)

7. AMPLITUDE to 30.0 X1 (30.0 volts peak-to-peak)

c. Connect an oscilloscope as follows:

1. Vertical input to SIGNAL

2. Horizontal input to SWEEP

NOTE:

Vertical and Horizontal amplifiers of the oscilloscope must be DC coupled whenever used with the SERVODYNE.

d. Adjust oscilloscope controls to obtain single sine wave display. Switch RANGE to:

C for digital models
X1.0 for 903A

The oscilloscope should now show a single sine wave of:

9.0 cps for 902D, 902DSG
90. cps for 902DK
9 cps for 903A

e. Repeat for remaining ranges. Frequency should drop one decade per range and show a single sine pattern. Hold START button in approximately two seconds if oscillation does not start immediately.

NOTE

Operation of START is as follows: when START is pushed, signal returns immediately to zero and remains as long as button is held. Sweep continues to free-run. When START is released, signal will start (from zero) in a positive direction and sweep will come into synchronization after one or less cycles.

NOTE: (cont'd)

START button should be held in for a minimum of two seconds for best results.

f. Return RANGE to maximum clockwise and vary frequency. The sine pattern should remain in sync.

g. Set frequency to 10 CPS.

h. Set UNMOD-MOD switch to MOD, the pattern should remain 30 volts peak-to-peak and appear as shown in figure 3-4.

NOTE:

This trace on the oscilloscope is the external carrier, modulated by the 10 CPS function frequency. If internal carrier is supplied perform step i, if not supplied proceed with step j.

i. Set CARRIER CPS to 60, then 400; pattern should be 60 and 400 CPS modulated by 10 CPS.

j. Set WAVEFORM switch to SQUARE: modulation envelope should change to square waves.

k. Return UNMOD-MOD switch to UNMOD and WAVEFORM switch to SINE.

l. Set frequency to 90 CPS; pattern should now be 90 CPS sine wave, with sweep starting at zero-degree point of waveform.

m. Rotate PHASE SHIFT to 90 degrees, 180 degrees, 270 degrees, and zero degrees. Start of sweep should correspond to 90 degrees of the waveform.

n. Continue through cycle; start of each sweep should correspond to degree starting point.

NOTE:

The following is for units including an SF-1 or SF-2.

o. Set WAVEFORM switch to Triangle. Note triangle of same amplitude and phase as the sinewave.

p. Set WAVEFORM switch to Trapezoid; note trapezoid of same amplitude and phase as triangle and sinewave. Vary the SLOPE (screwdriver adjustment), trapezoid will vary from a slightly clipped triangle to approximately a squarewave.

For units with SF-1 or SF-3:

q. Observe waveform at PHASE SHIFT jack, this will be a sinewave approximately 80V P-P.

r. Move the UNMOD-MOD switch to MOD, observe the waveform at PHASE SHIFT MOD jack, this will be a modulated sinewave approximately 25V P-P.

s. Connect the HORIZONTAL input of the scope to PHASE SHIFT MOD. Connect the VERT input to SIGNAL. Observe spoke pattern on scope, vary the PHASE SHIFT dial, the pattern will be recognized as a modulated Lissajous.

Figure 3-1. SERVODYNE Test Set (Model 903A)

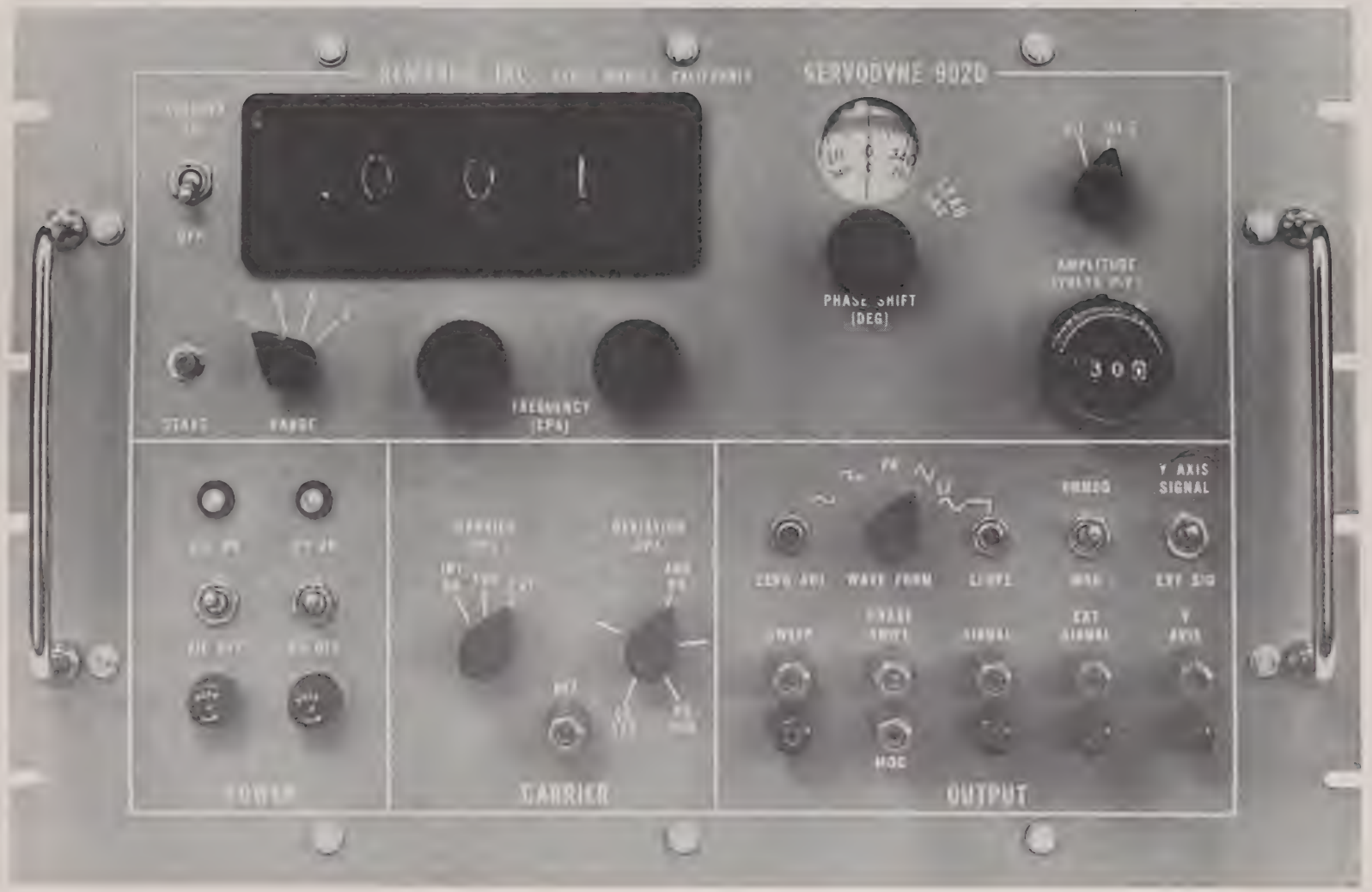


Figure 3 2. SERVODYNE Front Panel (Model 902D)

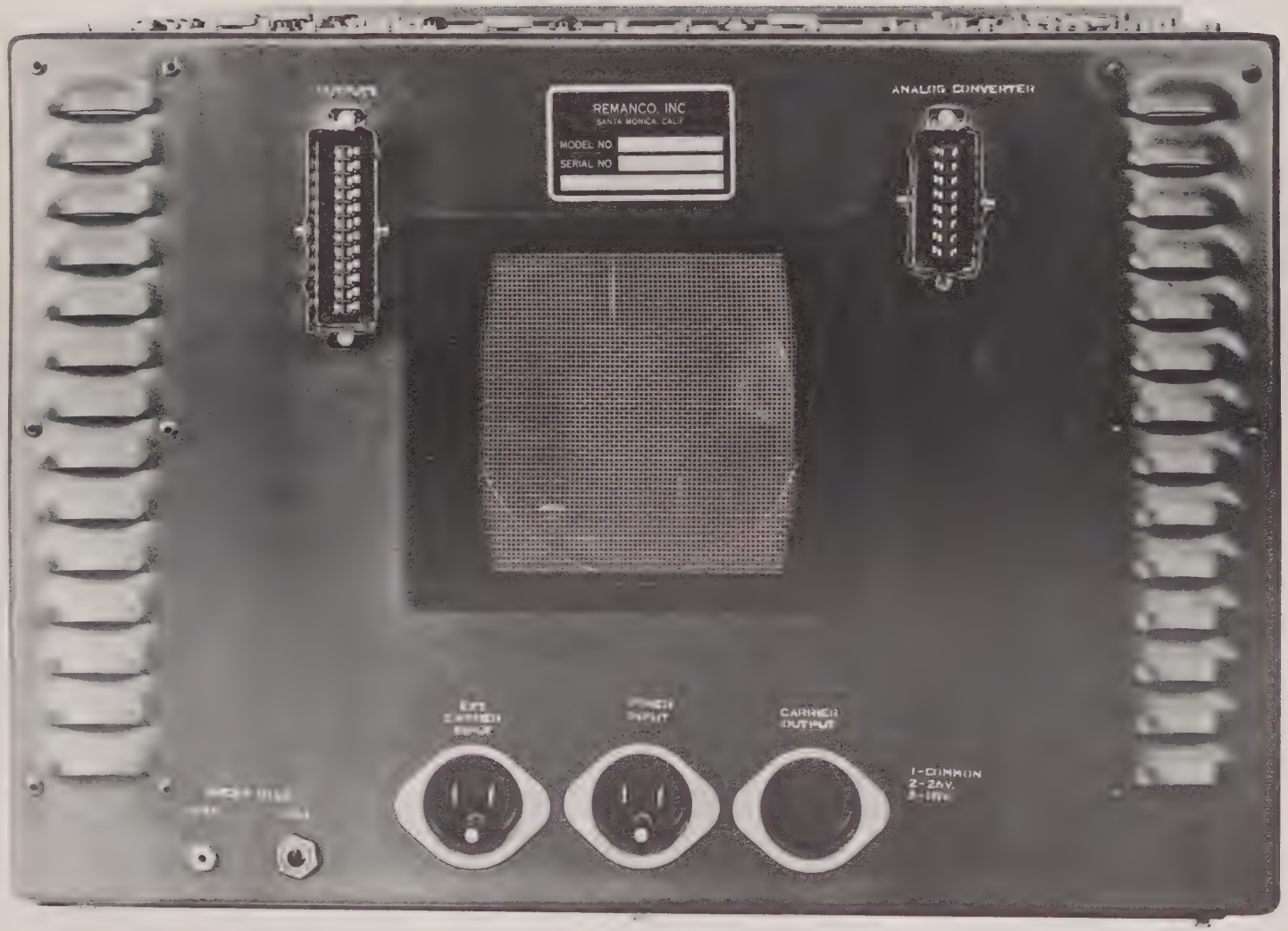


Figure 3-3. SERVODYNE Rear View

(a) Sine Modulation

Figure 3-4. Modulated Output Signals

4.0 TECHNICAL DESCRIPTION

4.1 General Construction

The unit may be physically described in terms of the front panel (1A7), the main chassis (1), and six plug-in modules, identified as follows:

1. Carrier Module (1A1) plus carrier plug-in (1A7A1) (optional accessories).
2. Low Frequency Oscillator Module (1A2)
3. Sweep and Modulator Module (1A3)
4. Special Function Module (1A5)
5. Extended Frequency Module (1A6)
6. Power Supply Module (1A4)

4.1.1 Front Panel

The front panel components, shown in wiring diagram 1A7, are described in the paragraphs applicable to the circuit in which they are used.

4.1.2 Main Chassis

The main chassis components, shown in wiring diagram 1, include filament transformer T1, high voltage transformer T2, external carrier input transformer T3. Terminal board TB3 is shown wired for 115V AC operation, as normally supplied. It is shown also in reference, with the jumpers changed to the connections necessary for 230V AC operation.

4.1.3 Carrier Module (1A1)

The carrier module contains the carrier oscillator circuit (V5 and V6), the carrier amplifier circuit (V1, V2, V3 and V4), and the regulator circuit (V7, V8, and V9).

4.1.4 Low Frequency Oscillator Module (1A2)

The low frequency oscillator module contains the low frequency oscillator circuit (V11, V12, V13, V14, V15, V16, V10, V9, and V8A), the inverter A circuit (V1, V2 and V3A), the inverter B circuit (V4, V5, and V3B), and the output amplifier circuit (V6, V7, and V8B).

4.1.5 Sweep and Modulator Module (1A3)

The sweep and modulator module contains the sweep squaring amplifier (V1 and V2), the sweep generator circuit (V7 and V8), the squaring amplifier circuit (V3 and V4), the squaring inverter circuit (V9 and V10), the phase amplifier circuit (V5 and V6) and the modulator amplifier circuit (V11 and V12). It also provides socket mounting for the sealed modulator unit.

4.1.6 Extended Frequency Module (1A6)

This module contains the necessary capacitors for low frequency range extension.

4.1.7 Special Function Module (1A5)

The SF module contains circuits for obtaining the triangle and trapezoid. In addition, a modulation circuit is provided for modulation of the phase shift signal.

4.1.8 Power Supply Module (1A4)

The power supply module contains the unregulated +430V DC supply, the regulated +300V DC supply circuit, (V1, V2 and V3), the regulated -300V DC supply circuit (V4, V5, V6, and V7), and the modulator driver amplifier circuit (V8).

4.2 Functional Description - Overall

4.2.1 General

Refer to SERVODYNE Block Diagram, drawing No. 502117. The heart of the unit is a precision low frequency function generator. Two outputs in quadrature

are taken from the low frequency oscillator. Each of these is applied to an inverting amplifier and to a sine-cosine potentiometer. The outputs of the inverting amplifier are also applied to the sine-cosine potentiometer, which supplies a variable phase-shifted output in reference to the signal output from the SERVODYNE. The phase shift output is made available at the front panel to be supplied to the X axis of an oscilloscope for the generation of Lissajous figures. It is also supplied to a squaring amplifier, thence, to a sweep generator. The resulting sawtooth signal produced by the sweep generator is delivered to the appropriate front panel terminal.

4.2.2 Output Signal

4.2.2.1 Sine-Wave

When the equipment is set up for sinusoidal output, the zero-degree signal from the low frequency oscillator is applied through the WAVEFORM selector switch to the modulator and UNMOD LVL control. In the UNMOD mode, the UNMOD LVL adjustment and the AMPLITUDE control determine the amplitude of the output signal.

4.2.2.2 Square Wave

With the WAVEFORM switch in the SQUARE position, the 180 degree signal from inverter B is applied to a squaring amplifier. In the case of unmodulated output conditions, it is then applied to the output circuits as in the sinusoidal mode. For modulated output, the output of the squaring amplifier is split and applied to the modulator, with one side passing first through the square wave inverter.

4.2.2.3 PK (Peak Reference)

With the WAVEFORM switch in the PK position, the output of the squaring amplifier is a steady state positive level, this in turn is applied to the output circuits as in the sinusoidal mode. For modulated output, the output of the squaring amplifier is split and applied to the modulator, with one side passing first through the square inverter. The output in this mode (MOD) will be the carrier signal only, at the

selected amplitude.

4.2.2.4 Triangle

When the WAVEFORM switch is placed in the TRIANGLE position the zero degree signal from the LFO is applied to the Triangle Generator. The output of the triangle generator feeds a clamped amplifier, whose gain is such that the triangle passes through it, without being clamped. In the UNMOD mode the triangle is applied to the output circuitry as in the sinusoidal mode. In the MOD mode the triangle is fed from the clamped amplifier to the modulator, with one side first passing through the clamp inverter.

4.2.2.5 Trapezoid

With the WAVEFORM switch in the TRAPEZOID position, the signal passes through the triangle amplifier as in the triangle mode, however, the gain of the clamp amp has been increased, so the input signal level to the clamp amplifiers causes clamping of the top and bottom of the triangle, forming a trapezoid. The slope of the trapezoid is varied by changing the gain of the clamp amplifier. In the UNMOD mode the trapezoid passes through the output circuitry as in the sinusoidal mode. In the MOD mode the output of the clamp amplifier is applied to the modulator, with one side first passing through the clamp inverter.

4.2.2.6 Modulation

Modulated output from the SERVODYNE is provided through the use of either an externally supplied carrier or one generated by the carrier module. The appropriate carrier signal is routed by the CARRIER CPS switch to the modulator driver amplifier. The push-pull output from the driver is applied to the modulator. The modulated signal output of the modulator is delivered to the modulator amplifier and thence, to the output circuit through the MOD/UNMOD switch.

4.2.3 Carrier Signal Output

Provisions for supplying carrier frequency power to

the servo system under test are contained in the carrier module. An output signal from the carrier oscillator is applied to the carrier amplifier. Approximately 16 watts of carrier power from the amplifier is available at a rear panel connector.

4.3 Detailed Description

4.3.1 Operational Amplifiers

A typical operational amplifier is shown in simplified form, together with some of the feedback configurations which are employed in various usages, in figures 4-1 and 4-2. These amplifiers are utilized extensively throughout the SERVODYNE test set. An identifying characteristic of the operational amplifier, where the open loop gain of the basic amplifier is high, may be stated thus:

$$\frac{E_o}{E_{IN}} = \frac{-Z_f}{Z_i}$$

where

Z_i = transfer impedance function of the input impedance.

Z_f = transfer impedance function of the feedback impedance.

Thus, the signal output is dependent entirely upon the impedance characteristics, and virtually unaffected by changes in stage gain. Where applicable, provision is made for the correction of drift error by balancing the amplifier; the output is adjusted for zero DC level. In the SERVODYNE test set operational amplifiers are used as inverters, isolators (voltage followers) and amplitude limiters.

4.3.2 Low Frequency Oscillator (1A2)

Figure 4-3 is a simplified block diagram of the oscillator. The complete circuit is shown in schematic 1A2 at the rear of the manual. Three operational amplifiers and four 45-degree RC phase shift sections are connected to form a unique phase shift

oscillator. Two of the amplifiers are connected in the voltage follower configuration to permit picking off a zero-degree reference signal and a 90 degree signal. The former is taken from the cathode of V16 and the latter from the cathode of V13. These amplifiers each operate at a gain of three. The third amplifier provides a gain slightly higher than unity in order toprovide the proper conditions to support oscillation. Zener diodes CR1 and CR2 limit the signal voltage on the cathode (pin 3) of V8A, thereby affording a constant oscillator output voltage. The precision capacitors are fixed in value, and are selected for each range by the RANGE switch. In Model 903A, the precision four-section potentiometer provides the variable resistance for each RC section. A cam arrangement on the frequency control mechanism drives the potentiometer is a manner compensatory to the non-linear characteristic of the RC networks, providing linear calibration of the frequency dial. In the Model 902D, the cam and pottentiometer arrangement is replaced by two rotary switches, and sections of fixed precision resistors. These switched precision resistors provide the variable resistance for the RC frequency determining networks. Potentiometer R86 provides the means for balancing the oscillator output for zero DC level.

4.3.3 Inverters A and B (Module 1A2)

Inverters A and B, shown on Schematic 1A2, are operational amplifiers having unity gain. Inverter A operates on the 90 degree signal from the low frequency oscillator to provide a 270 degree input to the phase shifter. Potentiometer R40 is the amplifier balance control. Inverter B operates on the zero-degree oscillator output to provide a 180-degree input to the phase shifter. Potentiometer R41 is the amplifier balance control.

4.3.4 Phase Shifter

The phase shifter is shown in the Block Diagram. The PHASE SHIFT control is a dual sine-cosine potentiometer with each section driven in push-pull, giving 0^{o}, 90^{o}, 180^{o}, and 270^{o} signals. The outputs are

supplied to a summing amplifier to provide the desired phase-shifted signal. Note that the Phase Amplifier adds another 180° shift, so the final output at the PHASE SHIFT terminal is always 180° from the potentiometer sum signal. Referring to the Block Diagram, assume the upper arm to be at 9 o'clock and the lower arm at 6 o'clock. The upper arm will be at ground and have no signal; the lower arm signal will be full amplitude, 180°. The sum signal will be 180°, but the output of the Phase Amplifier will be 0°. This pot position is the 0° calibration of the PHASE SHIFT dial. As the PHASE SHIFT dial is set at 90°, 180° and 270°, a constant amplitude output of the corresponding angle is obtained. At positions of the potentiometer other than those where one of the four reference signals is selected, the wipers pick off signals from two of these simultaneously, in a proportion dependent upon the shaft position. When summed and inverted, a resultant sine wave is obtained which is shifted with respect to the main 0° signal by the desired number of degrees.

4.3.5 Phase Amplifier (Module 1A3)

The phase amplifier, shown on schematic 1A3 is an operational amplifier with a summing input circuit consisting of resistors R34 and R35. The voltages from the phase shift potentiometer wipers are applied to them for summing and amplification. The resultant signal is made available at the PHASE SHIFT terminal on the front panel for oscilloscope sine sweep drive, and is also supplied to the input of the sweep squaring amplifier to be used in the triggering of the sawtooth sweep signal. Potentiometer R42 provides amplifier balance control.

4.3.6 Sweep Squaring Amplifier (Module 1A3)

The sweep squaring amplifier, shown on Schematic 1A3, is a high gain operational amplifier which changes state rapidly upon excursion of the sinusoidal input voltage from the zero reference leve. The square wave output is taken from the cathode of V2B and supplied as a synchronizing voltage to the input circuit of the sweep generator.

4.3.7 Sweep Generator (Module 1A3)

The sweep generator, shown on Schematic 1A3, is an operational amplifier connected as an integrator. With a negative input voltage, no sync pulse, and the 20 volt Shockley diode CR8 connected from output to input, the circuit will free-run and form a 20 volt sawtooth whose period depends upon the input voltage (E_{in}), input resistor (R), and integrating capacitor (C). Values of C are selected by the RANGE switch to correspond with the LFO range. In the 903A, E_{in} is varied by the FREQUENCY dial. In the 902D, R is varied by the FREQUENCY switches. The sweep is synchronized with the LFO frequency by injecting trigger pulses into CR8. Whenever the voltage across CR8 reaches 20 volts, the diode fires. This connects output to input and the output voltage returns to zero. The sync pulses are generated by Blocking Oscillator plug-in 1A3A2 which is fed from the sweep squaring amplifier.

4.3.8 Output Amplifier (Module 1A2)

The output amplifier, shown on schematic 1A2, is a unity gain voltage follower fed from the AMPLITUDE control. This provides negligible loading of the potentiometer wiper and gives optimum accuracy and linearity. Amplifier balance is provided at pin 7 of V6 by ZERO ADJ potentiometer on the front panel. This amplifier provides a low impedance output to the SIGNAL terminal on the front panel.

4.3.9 Carrier Oscillator (Module 1A1)

This oscillator, shown in Schematic 1A1, is similar in operation to the low frequency oscillator. Two frequencies may be selected by the CARRIER CPS switch. The accessory module normally provides a 60 CPS and a 400 CPS capability, but other frequencies may be made available through the use of a different carrier plug-in unit. As in the low frequency oscillator, isolation between 45-degree RC sections permits pick off of a zero-degree and a 90-degree signal. Constant amplitude output is maintained through limiting by Zener diodes CR1 and CR2. Front

panel deviation potentiometer provides a means of obtaining a deviation of approximately 7 percent from the nominal carrier frequency.

4.3.10 Carrier Amplifier (Module 1A1)

The carrier amplifier, shown on schematic 1A1, utilizes a basic Williamson circuit to amplify the output from the carrier oscillator. Feedback is taken from one winding of transformer T1 (terminal 10) and applied to the cathode of V1A. The amplifier supplies 16 watts of power which may be used to energize the line phase of a two-phase servo motor.

The 115 volt output is held constant by regulator circuit V7, V8, and V9. V9B is used as a voltage-controlled shunt circuit between the output of the carrier oscillator and the input of the carrier amplifier. The gain of V9B is controlled by the dc output of the regulator amplifier V7/V8, which is proportional to the 115 volt signal from T1. The 115-volt signal is fed from T1 to T2, rectified (negative), and applied to V7-2. CARRIER LVL R34 supplies a positive dc reference voltage to V7 grid. In operation, the summing point V7 grid will remain at zero. If the 115 volt output tends to decrease, a positive voltage will appear at V7 grid. This will cause a more negative voltage at V9B grid, increasing the gain. This will continue until V7-2 returns to zero, and the output is 115 volts. Since the sensing voltage is taken from the 115 tap, the 26 volt tap will not be regulated for variations in load, but only for line voltage variation. The CARRIER LVL control allows adjustment of the output to exactly 115 volts for calibration.

Since it is usually desired that the output of the carrier amplifier be 90° with respect to the modulated carrier signal (SIGNAL output from front panel), V9-2 is normally connected in the "STD" (green) position shown in the schematic. However,if the carrier amplifier output is to be 0° with respect to the

modulated signal, this is accomplished by moving V9-2 wire from the green terminal to the red terminal. These points are located directly over V9 socket and colored as noted. No readjustment of CARRIER LVL should be required.

4.3.11 Modulator Driver (Module 1A4)

The modulator drive amplifier, shown on schematic 1A4, utilizes the 0-degree output signal from the carrier oscillator. This signal is taken across the grid resistor (R28) of 1A1V6B, which also serves as grid return for the input stage of this amplifier.

4.3.12 Modulator (Module 1A3)

The modulator is a sealed plug-in unit, not shown in the drawings. It is a high level electronic multiplier. The carrier and low frequency signals are applied in push pull to the multiplier. The output is a suppressed carrier signal suitable for driving AC servo motors or transformers. The output of the modulator is applied to the modulator amplifier.

4.3.13 Modulator Amplifier

The modulator amplifier is an operational amplifier connected as a variable-gain amplifier. It is shown on schematic 1A3. The amplifier balance adjustment is provided by potentiometer R76. The modulation level is set by varying the feedback impedance by means of potentiometer R112.

4.3.14 Squaring Amplifier (Module 1A3)

The squaring amplifier, shown on schematic 1A3, is similar to the sweep squaring amplifier. It utilizes the 180-degree signal from inverter B to generate the square wave output signal of the SERVODYNE test set. Limiting of the peak amplitudes of the square wave is accomplished by the circuit made up of diodes CR3 and CR4, and the voltage divider containing potentiometers R97 and R100. Limiting of the grid excursions of V4B controls the voltage peaks

across the cathode resistance which constitute the output signal. The potentiometers provide a means of calibrating the amplitude control for operation of the SERVODYNE in the square wave mode.

4.3.15 Squaring Inverter (Module 1A3)

This operational amplifier, shown in schematic 1A3, is connected as a unity gain inverter. It supplies a signal which is used in conjunction with the output from the squaring amplifier to provide push pull drive for the modulator.

4.3.16 Extended Frequency Module (1A6)

This module contains banks of precision temperature compensated capacitors which allow the Servodyne low frequency range to be extended one decade.

4.3.17 Special Function Module (1A5) (SF1)

Refer to Schematic 1A5.

4.3.17.1 Triangle Generator (Module 1A5)

This circuit is an operational amplifier with a diode shaping network in the feedback loop. The shaping network varies the gain in proportion to the input so that a sine wave input gives a triangular output.

4.3.17.2 Clamp Amplifier (Module 1A5)

This circuit is an operational amplifier whose gain is varied by changing the value of the input resistor. In the trapezoid mode clamping on the output converts a high amplitude triangle into a trapezoid. In the Triangle mode, the gain of the amplifier is such that the triangle amplitude is just under the clamping level.

4.3.17.3 Clamp Inverter (Module 1A5)

An inverting type operational amplifier is used here to obtain signals 180° out of phase to drive the modulator.

4.3.17.4 Phase - Shift Modulator (Module 1A5)

The phase shift modulator consists of the carrier amplifier, function inverter, modulator (Z1) and modulator amplifier. The carrier amplifier converts the single-ended carrier signal to high-level push-pull to drive the modulator. The function inverter inverts the phase-shift signal to give push-pull function drive for the modulator. The modulation amplifier converts the modulator signal to low impedance for the PHASE SHIFT MOD terminal.

4.3.18 Power Supply (Module 1A4)

The power supply, shown on schematic 1A4, consists of a +300V DC and a -300V DC supply which employ silicon rectifiers and vacuum tube regulation. Filament transformer T1 and high voltage transformer T2 are located on the main chassis (wiring diagram 1). The +300V supply contains 1 percent dividers which are not adjustable. However, the -300V supply can be set to exactly -300 volts and the +300 will then be within 1%. The supplies are designed to compensate for line variations of ±10% without affecting the output voltage.

4.3.18.1 -300V Supply

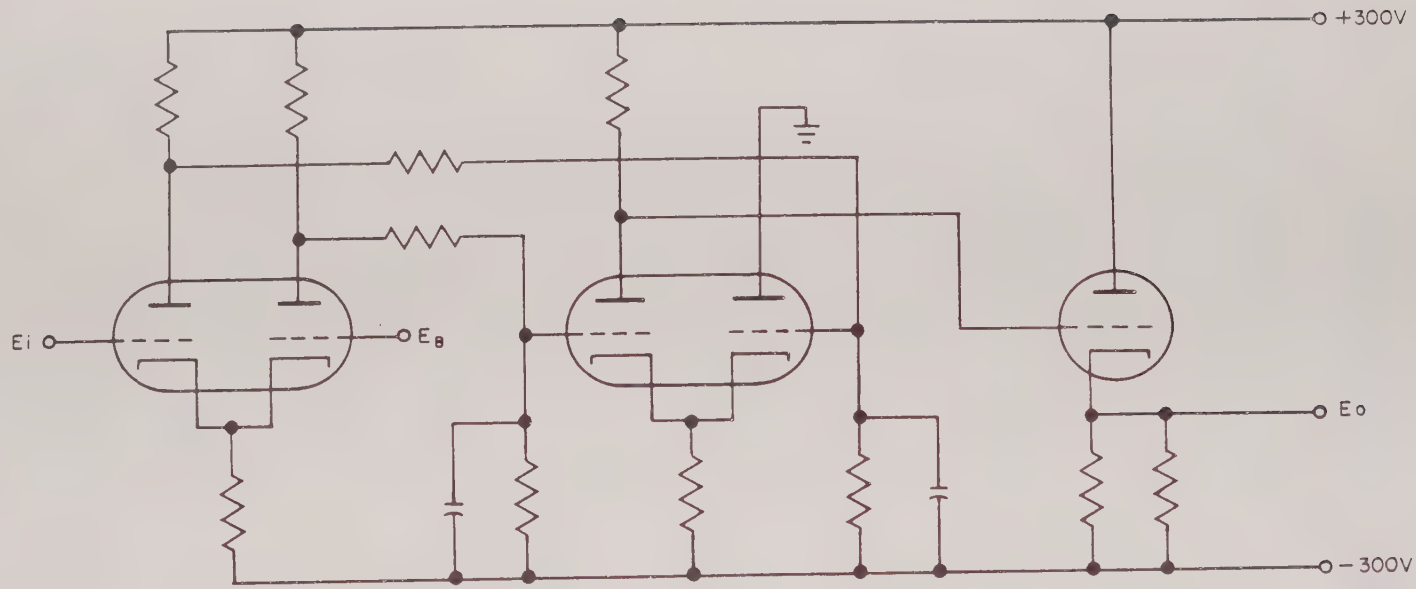
Gas-tube regulator V6 provides the reference grid voltage for differential amplifier V7. The input voltage is taken from the divider consisting of resistors R19 and R20. R32 (-300V ADJ) allows setting the -300 volts exactly. Error signals are applied to the grids of amplifier V5; the output is fed to the grids of series regulator V4, which serves as a variable resistance to oppose the original variation.

4.3.18.2 +300V Supply

The +300V DC supply uses -300 volts DC as a reference. It contains two differential amplifiers in cascade to provide a high degree of regulation. The output of the second amplifier, V2, drives series regulator V1. V3 senses the voltage at R9-R10 junction and the loop holds this voltage at zero. Since R9 and R10 are equal, the junction will be zero only when the +300

and -300 are of equal magnitude.

Therefore, the -300V DC supply must be operating properly in order that the correct output be obtained from the +300V DC supply. The two supplies act in opposition to each other in that a tendency toward a negative increase in the negative supply will be reflected in a positive increase in the positive supply. This tends to minimize unbalance of the operational amplifiers. The unregulated input to V1 (approximately +430V DC) is used as B+ for the 16-watt power amplifier in carrier module 1A1.

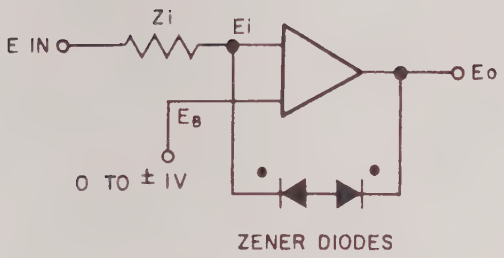


TYPICAL OPERATIONAL AMP

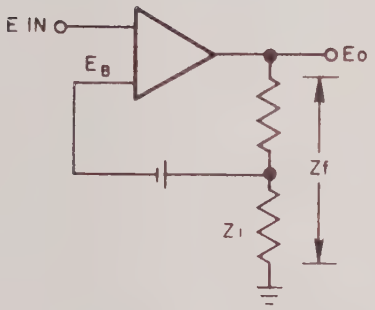
NOTES:
Ei - AMP INPUT
E_B - AMP BALANCE
Eo - AMP OUTPUT

Figure 4-1. Operational Amplifier - Basic Circuit

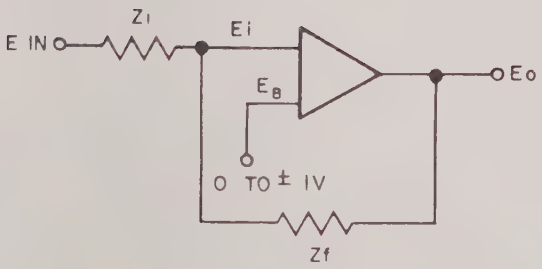
TYPICAL USE CONFIGURATIONS



LIMITER

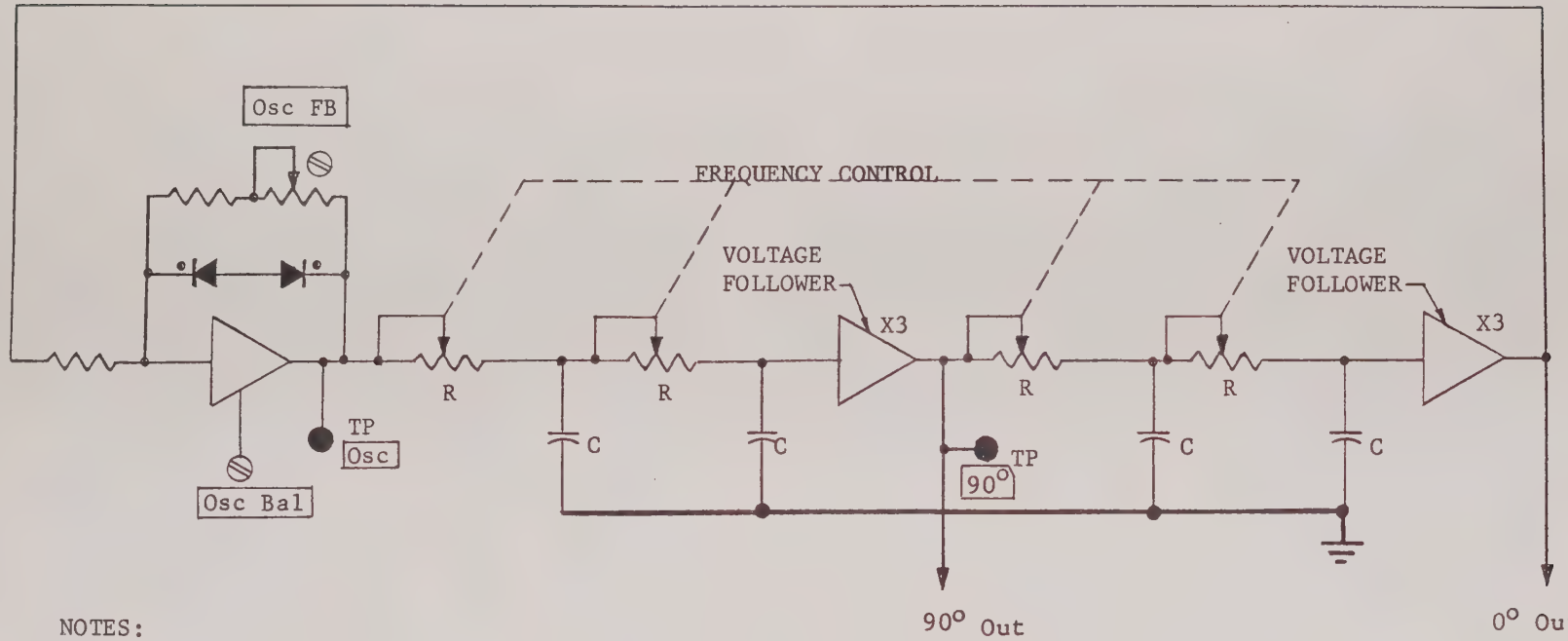


VOLTAGE FOLLOWER



INVERTER

Figure 4-2. Operational Amplifier - Typical Usage



NOTES:

R = 50 to 500K, 1%

C = 4 SETS OF 1% CAPACITORS

DECADE RANGE			
10 TO 100	CPS	0.0316	MFD
1 TO 10	CPS	0.318	MFD
0.1 TO 1.0	CPS	3.18	MFD
0.01 TO 0.1	CPS	31.8	MFD

$$f = \frac{1}{2\pi RC}$$

Figure 4-3. Basic Circuit - Low Frequency Oscillator

5.0 ADJUSTMENT AND CALIBRATION PROCEDURES

5.1 Test Equipment Required

The following test equipment (or equivalent) is required to calibrate and adjust the SERVODYNE circuits:

DC Oscilloscope	Hewlett-Packard Model 120A
DC VTVM	Hewlett-Packard Model 412A
*AC VTVM	Hewlett-Packard Model 400D
Electronic Counter	Hewlett-Packard Model 523 DR
Audio Oscillator	Hewlett-Packard Model 200CD

5.2 Preliminary Procedures

5.2.1 Provide connections to rear panel connectors as follows (see figure 3.3).

a. POWER INPUT to 115V AC source

NOTE:

If equipment is to be used with 230V AC power, it is first necessary to rearrange the jumpers on terminal board TB3 as shown on the chassis wiring diagram 1. The fuses must also be changed as stated in Section 3.

b. EXT CARRIER INPUT to 115V AC external carrier supply.

5.2.2 The following preliminary front panel switch settings are required:

a. Set filament switch to the ON position, and allow the equipment to warm up for 15 minutes.

b. Set B + switch to ON position.

*If Internal Carrier Module is supplied.

c. PHASE SHIFT dial to zero degrees

d. WAVEFORM switch to SINE

e. UNMOD-MOD switch to UNMOD

f. FREQUENCY and RANGE for 90 cps.

g. CARRIER CPS switch to EXT.

NOTE:

If the test set contains the PR-64 carrier module, refer to paragraph 5.7 before performing calibration procedures.

5.3 Power Supply

5.3.1 -300 Volts

Measure voltage at -300 test point. If meter is 1% or better, set to -300 volts with -300 ADJ.

5.3.2 +300 Volts

Measure voltage at +300 test point. Voltage should be +300 $\pm$ 2%.

5.4 Operational Amplifier Balance

In certain instances a module will have to be removed from the cabinet and connected to the test set by means of an interrupter cable during the calibration procedure. However, calibration for the most part can be accomplished with the modules in the cabinet. Figure 5-1 shows the location of the module adjustment controls and test points.

5.4.1 Low Frequency Oscillator and Inverters

Balancing of the low frequency oscillator and inverters is accomplished as follows:

a. Connect the DC input lead of the oscilloscope to the OSC test point.

b. Rotate OSC F.B. control to the full counter-clockwise position; oscillations should cease.

NOTE:

If oscillations do not cease, place a jumper across R73 (100K ohms ± 1%) in the low frequency oscillator. This will insure a non-oscillating condition.

c. Connect oscilloscope to FUNCT 0° test point (Sweep & Mod) and adjust the OSC BAL control to obtain a zero DC level indication on the oscilloscope.

d. Connect the DC input lead of the oscilloscope to the FUNCT 180° test point on the sweep and modulator module and adjust the DC level to zero with the B-BAL control on L.F.O., the low frequency oscillator module.

e. Connect the DC input lead of the oscilloscope to the 90° test point. Read the DC voltage. This voltage should be 0 ± .5 volts.

f. Connect the oscilloscope to 270° test point and adjust A BAL to obtain a voltage equal in amplitude but opposite in sign to that read at the 90° point. For example:

90° reads + .2 volts
270° adjust to -.2 volts.

5.4.2 Output Amplifier

Balance the output amplifier as follows:

a. Connect oscilloscope input to SIGNAL terminal on the front panel.

b. Set AMPLITUDE dial to 000 (zero volts), and adjust ZERO ADJ control on front panel to obtain a zero DC level indication on oscilloscope.

5.4.3 Phase Amplifier

Balance the phase amplifier as follows:

a. Connect the DC input of the oscilloscope to the upper (unmod) PHASE SHIFT terminal on the front panel and set PHASE SHIFT dial to 0^{o}.

b. Adjust PHASE BAL control to obtain a zero DC level indication on oscilloscope.

5.5 Special Function Module (1A5)

Remove the module from the unit and place on an extender cable. Balancing is as follows:

5.5.1 Function Inverter and Modulator Amp (SF-1, SF-3)

a. Connect DC vertical input of oscilloscope to MOD PHASE SHIFT terminal and throw UNMOD/MOD switch to MOD.

b. Temporarily short upper (unmod) PHASE SHIFT terminal to ground.

c. Adjust R6 and R25 of SF Module to obtain carrier null. Increase oscilloscope gain and adjust both R6 and R25 to get the signal which is both minimum amplitude and zero dc offset.

d. Remove short from PHASE SHIFT terminal and return UNMOD/MOD switch to UNMOD.

5.5.2 Triangle Generator (SF-1, SF-2)

a. Observe the DC balance at TRIANGLE test point with a DC coupled oscilloscope.

b. Adjust R48.

5.5.3 Clamp Amp (SF-1, SF-2)

a. Observe the DC balance at CLAMP AMP test point with a DC coupled oscilloscope.

b. Adjust R69 for zero DC balance.

5.5.4 Clamp Inverter (SF-1, SF-2)

a. Observe the DC balance at CLAMP INV test point with a DC coupled oscilloscope.

b. Adjust R91 for a zero DC balance.

5.6 Calibration

NOTE:

Remove the jumper, if used, across R73 in the low frequency oscillator.

5.6.1 Unmodulated Output

Calibration of the unmodulated output signal is accomplished as follows:

a. Set AMPLITUDE to 30 volts.

b. Connect oscilloscope input lead to the OSC test point on low frequency oscillator module (1A2).

c. Rotate OSC F.B. control in the clockwise direction until clipping occurs on both peaks of the waveform as shown in figure 5-2.

Vary frequency knobs or dial (D or X10 RANGE) to be sure clipping occurs at all frequencies. Return frequency to 90 cps.

NOTE 1:

Setting OSC FB unnecessarily high with heavy clipping will result in excessive distortion at the 90° and 270° outputs. This results in a distorted Lissajous pattern when making phase measurements and incorrect readings if a counter is used to check the phase dial as described in paragraph 5.6.7. Setting the clipping level too low (barely clipping) may cause loss of

amplitude accuracy and slow starting somewhere in the frequency range. Therefore, the clipping level should be set as shown in figure 5-2.

d. Connect oscilloscope input to SIGNAL terminal on the front panel.

e. Adjust UNMOD LVL control to obtain a 30V peak-to-peak sine wave as measured on the oscilloscope.

f. Set WAVEFORM switch to SQUARE.

g. Adjust SQ-POS control to obtain a 15V positive peak, and SQ-NEG control to obtain a 15V negative peak; the total excursion will be 30V peak-to-peak.

NOTE 2:

The following adjustments are for SERVODYNES containing SF-1 or SF-2 (Module 1A5).

h. Set WAVEFORM switch to TRIANGLE.

i. Connect oscilloscope to TRIANGLE test point of SF module. Adjust TRIANGLE pot for slight overpeaking at triangle tips. If peaks are not equal, adjust R103 (on SF chassis) for symmetry. Reduce TRIANGLE pot and obtain optimum tips of triangle.

j. Connect oscilloscope to SIGNAL terminal on front panel and set WAVEFORM switch to TRAPEZOID.

k. Turn front panel SLOPE control full clockwise. Waveshape should be a trapezoid (clipped triangle). Adjust SF POS CLAMP for +15 volt clipping and NEG CLAMP for -15 volt clipping; total peak-to-peak to be 30 volts.

l. Return WAVEFORM switch to TRIANGLE.

m. Adjust SF AMPL pot so triangle tips are ±15 volts but not quite clipped.

n. Return WAVEFORM switch to TRAPEZOID. Turn panel SLOPE control through its range to check slope variation; leave near center of range.

NOTE:

Setting of TRIANGLE depends on setting of LFO OSC FB. Triangle shape may be optimized at any time by adjusting SF TRIANGLE and AMPL pots with oscilloscope connected to front panel SIGNAL terminal. Do not change OSC FB setting to vary triangle shape.

5.6.2 Modulated Output

The modulated output is calibrated in the following manner:

a. Connect oscilloscope to SIGNAL terminal on front panel.

b. Set WAVEFORM switch to SINE.

c. Set UNMOD-MOD switch to MOD

d. Turn AMPLITUDE to 30.0 volts p-p.

e. With CARRIER CPS switch at EXT, a modulated carrier should appear. Set FREQUENCY low enough to obtain a well defined envelope. Temporarily disconnect external carrier by pulling rear EXT CARR INPUT plug. Turn up oscilloscope gain to observe DC unbalance.

f. If DC unbalance exceeds ± 0.2 volts, temporarily place sweep and modulator 1A3 on interrupter cable and adjust MOD BAL pot on 1A3 chassis for zero volts in step (e). Replace module.

g. Replace EXT CARR INPUT plug and connect oscilloscope to CARRIER REF terminal on front panel.

1. If PR-64 Carrier Module is installed:

   Set CARRIER CPS switch to INT and measure CARRIER REF voltage supplied by the internal carrier. Switch CARRIER CPS to EXT and adjust EXT CARR LVL to give the same CARRIER REF voltage.

2. If PR-64 Carrier Module is not installed:

   Set CARRIER CPS switch to EXT and adjust EXT CARR LVL to give 15 volts peak-to-peak at CARRIER REF terminal.

h. With oscilloscope connected to SIGNAL terminal and a well-defined modulation envelope using EXT carrier, adjust MOD LVL on 1A3 panel for 30 volts peak-to-peak envelope. If internal carrier is supplied, switching CARRIER CPS to INT should also give 30 volts peak-to-peak envelope.

i. Switch WAVEFORM to SQUARE. If left and right halves are not identical in amplitude, balance by slight adjustment of SQ NEG control. (do not change SQ POS control)

j. Switch WAVEFORM to PK. Continuous 30V p-p carrier should appear.

k. If SF module is supplied, switch WAVEFORM to TRIANGLE and TRAPEZOID. If left and right halves of trapezoid are not of equal amplitude, balance by adjusting NEG CLAMP control on SF module.

5.6.3 Sweep Adjustment - Digital Models

a. Set WAVEFORM switch to SINE.

b. Connect oscilloscope horizontal to SWEEP, vertical to SIGNAL.

c. Set FREQUENCY to 99. CPS.

d. Adjust AMPLITUDE to 30 volts.

e. Connect DC VTVM to SWEEP BIAS -2V test point on rear of cabinet. If necessary, adjust

SWEEP BIAS ADJ pot for -2.0 volts.

NOTE:

The -2 volts above represents the voltage at V7-2, the input tube of the sweep generator in Sweep & Modulator 1A3. Proper adjustment of this voltage is important to insure proper sweep at all frequencies. This voltage should be checked if V7 is replaced.

f. REMOVE VTVM FROM -2V TEST POINT.

(Meter loading may affect sweep.)

g. Adjust oscilloscope gain for convenient vertical amplitude and hold START button in.

h. Adjust oscilloscope horizontal gain for 10 division horizontal line.

i. Release START button; sweep length should shorten to approximately 9 divisions. If not, adjust SWP control for 9 divisions. Turn RANGE switch through other positions, checking for stable pattern of approximately constant sweep length.

j. Return to 99. cps and try various frequencies in that decade for stable pattern of approximately constant sweep length.

5.6.4 Sweep Adjustment - Model 903A

a. Set WAVEFORM switch to SINE.

b. Connect oscilloscope horizontal to SWEEP, vertical to SIGNAL.

c. Set FREQUENCY to 100 CPS.

d. Adjust AMPLITUDE to 30 volts.

e. Connect DC VTVM to SWEEP BIAS -2V test point on rear of cabinet. If necessary, adjust SWEEP BIAS ADJ pot for -2.0 volts.

NOTE:

The -2 volts above represents the voltage at V7-2, the input tube of the sweep generator in Sweep & Modulator 1A3. Proper adjustment of this voltage is important to insure proper sweep at all frequencies. This voltage should be checked if V7 is replaced.

f. REMOVE VTVM FROM -2V TEST POINT.

(Meter loading may affect sweep.)

g. Adjust oscilloscope gain for convenient vertical amplitude and hold START button in.

h. Adjust oscilloscope horizontal gain for 10 division horizontal line.

i. Release START button; sweep length should shorten to approximately 9 divisions. If not, adjust SWP 10 CPS for 9 division sweep length.

j. Move FREQUENCY dial to 1 (10 cps) and adjust SWP 10 CPS for 9 divisions sweep length.

k. Return to 100 cps and readjust SWP 100 CPS if necessary.

l. Switch through lower positions of RANGE; check sweep sync and length.

5.6.5 START Adjustment

The START circuit is provided with an adjustment to allow optimum starting of the LFO. This becomes more important as lower frequencies are selected. When properly set, the START button will give a sine wave which starts at zero and moves in a positive direction to the proper amplitude on the first cycle. Adjustment is as follows:

a. Connect oscilloscope DC input to SIGNAL terminal and set up 1 CPS, UNMOD, SINE wave, 30V p-p.

b. With no signal to oscilloscope horizontal input, adjust oscilloscope vertical gain so the 1 CPS signal fills the screen vertically.

c. Depress START button for two seconds minimum and release. Note whether the first cycle overshoots or undershoots. If either occurs, turn START control (located on panel bracket with SWEEP, etc. adjustments) and repeat test until best starting is obtained.

5.6.6 Frequency

Frequency measurements are made with the WAVEFORM switch set to SQUARE. The electronic counter is used to insure that the frequency indication is within acceptable limits.

For best results, the counter should be used in PERIOD mode.

The carrier frequency, whether internal or external, may be measured at the CARRIER REF terminal on the front panel. (UNMOD-MOD switch at MOD.)

The 6.3V AC test point on Power Supply 1A4 is a convenient source of power line frequency and may be used as oscilloscope horizontal sweep for spot checking frequencies from about 10 to 600 cps by Lissajous pattern.

* 5.6.7 Phase

NOTE:

Excessive distortion due to too high a setting of OSC FB control will cause incorrect counter readings with maximum error at 90° and 270° points of PHASE SHIFT dial. Refer to paragraph 5.6.1

a. 0° and 180° may be checked accurately with the oscilloscope provided the oscilloscope has no phase shift. This must be checked by feeding

* Take phase shift data with UNMOD SINE signal.

the PHASE SHIFT (unmod) signal to horizontal and vertical axes simultaneously. Note direction of slope for this 0° pattern and see that the line is not split. If the oscilloscope shows phase shift and an attenuator probe is used, adjust the probe compensation to eliminate the phase shift.

b. If a complete phase shift calibration is required, the standard procedure such as given in the HP523 instruction manual may be used. The electronic counter is used to measure the time interval between corresponding zero crossings of the PHASE SHIFT and SIGNAL outputs of the servodyne. Recommended frequencies are 99 cps for digital models and 100 cps for the 903A. Phase readings will be direct in degrees if an external oscillator (such as HP200CD) is used. The HP200CD is set to exactly 3600 times the SERVODYNE frequency or approximately 360 KC. This ratio is established with the counter in period mode. Then with the counter in time interval mode and exactly zero degrees as indicated by the oscilloscope, the counter trigger levels are adjusted to operate at zero crossing and to indicate 0/3600. 180° may then be set on the oscilloscope and if the counter checks at $180.0 \pm .1$ the phase data may be run at any point on the dial. To insure best data, periodically recheck for 3600 period reading (readjust external oscillator if necessary) and 0/3600 time interval reading (readjust trigger levels if necessary).

NOTE:

IF OSC FB HAS BEEN TEMPORARILY REDUCED FOR COUNTER PHASE CALIBRATION CHECK, IT MUST BE RETURNED TO NORMAL. INCREASE OSC FB UNTIL UNMOD SINE SIGNAL IS 30.0 VOLTS PEAK-TO-PEAK AT FRONT PANEL SIGNAL TERMINAL (AMPLITUDE CONTROL AT 30.0 X1). OBSERVE CLIPPING AT OSC TEST POINT. IF UNMOD LVL HAS BEEN PROPERLY ADJUSTED, CLIPPING WILL BE NORMAL.

5.7 PR-64 Carrier Module Calibration

If the SERVODYNE is equipped with the PR-64 Carrier Module, check carrier output as follows:

5.7.1 115 Volt Adjustment

a. Set CARRIER CPS switch at INT, UNMOD-MOD to MOD.

b. Connect an AC voltmeter across pins 1 and 3 of CARRIER OUTPUT receptacle (pin 1 is common).

c. Adjust CARRIER LVL control to obtain 115V RMS.

d. Check voltage between pins 1 and 2 of CARRIER OUTPUT receptacle. This voltage should be approximately 26V RMS.

5.7.2 Carrier Phase

The 115V and 26V output of the Carrier Module is normally 90° with respect to the modulated signal and the CARRIER REF voltage. However, this may be 0° when so specified or may be changed whenever desired. Procedure is as follows:

a. Refer to Regulated Carrier Schematic 1A1. Note the 90° (green) and 0° (red) connections shown at V9-2. In the module, these points are adjacent to V9 socket and colored. To change the phasing, move the grid lead from one terminal to the other. Recheck the 115V RMS from pins 1 and 3 of CARRIER OUTPUT receptacle.

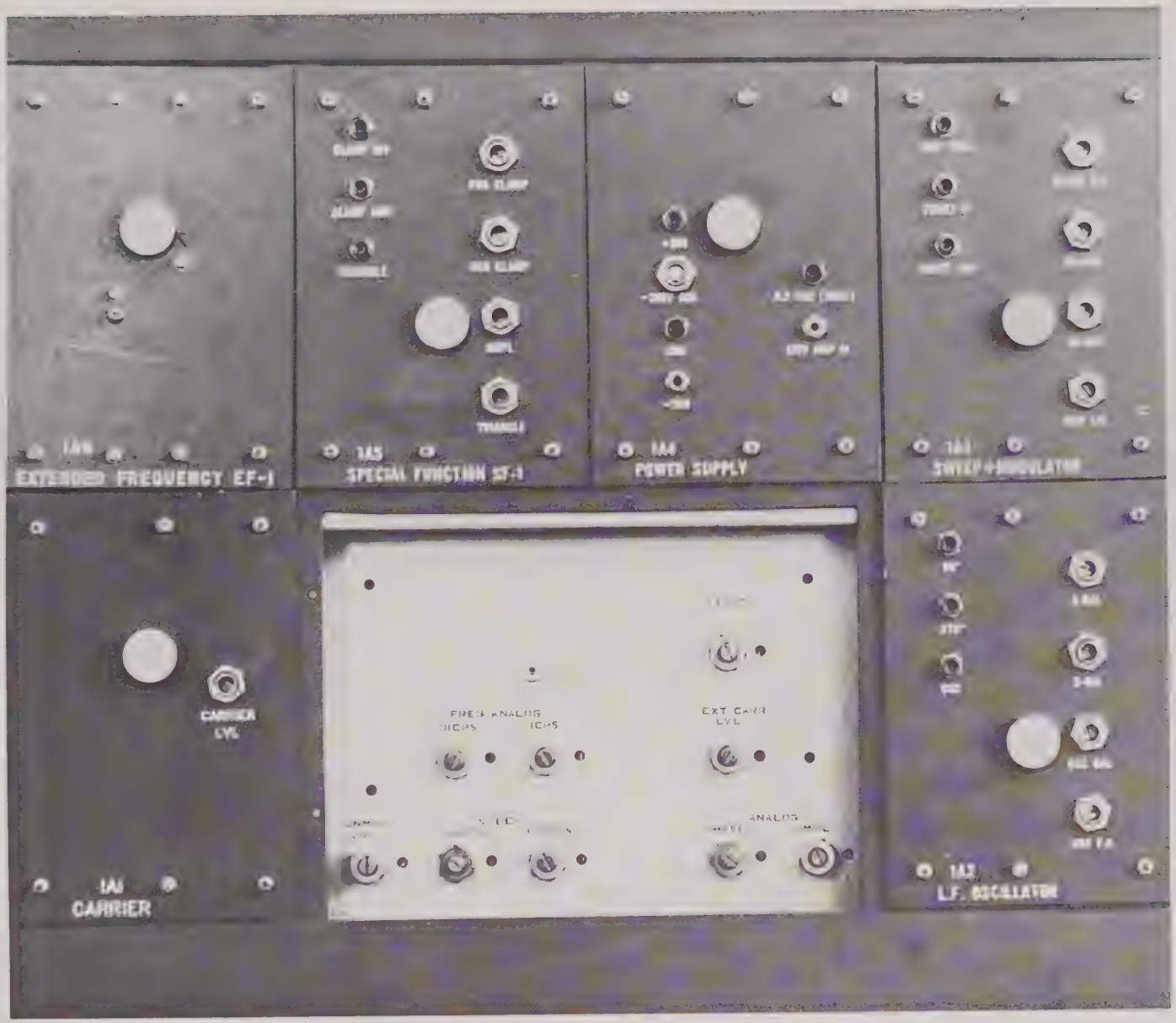
b. To check phasing:

1. Ground pin 1 of CARRIER OUTPUT.

2. Connect oscilloscope horizontal input to pin 2 (26V RMS) or pin 3 (115V RMS of CARRIER OUTPUT.

3. Connect oscilloscope vertical input to CARRIER REF terminal on front panel.

4. Turn CARRIER CPS switch to INT. The oscilloscope pattern should be 90° or 0° as selected in (a) above.



TOP VIEW, SERVODYNE MODEL 903A Fig. 5-1

CLIPPED SINE WAVE - Osc Test Point (LFO)

MODULATED SINE WAVE OUTPUT - SIGNAL TERMINAL

Figure 5-3. Output Waveforms

6.0 TEST PROCEDURES

6.1 General

The SERVODYNE may be used to test or analyze complete servo systems or portions thereof, such as AC or DC amplifiers or phase correction networks. It allows accurate measurement of gain and phase versus frequency, as well as transient response. The only accessory required is a DC oscilloscope, which in most cases need not have a calibrated vertical amplifier, since the AMPLITUDE control of the SERVODYNE is calibrated. The horizontal sweep is normally supplied by the SERVODYNE.

However, if the oscilloscope internal sweep is preferred, such as when displaying the rise or fall time of a feedback signal (demodulated for ac systems) the SWEEP signal from the SERVODYNE may be used as a negative trigger for the oscilloscope. The oscilloscope sweep speed may then be varied as desired. By adjusting the PHASE SHIFT dial, the trigger pulse can be moved to any portion of the cycle. This permits examination of any portion of the signal, at any sweep speed.

Use of a dual-trace oscilloscope will often facilitate measurements by observation of SERVODYNE and system signals simultaneously.

6.2 Phase Measurement

NOTE

> The slope of the zero-degree Lissajous pattern and the direction of the horizontal trace must be determined for the particular oscilloscope being used. Both axes of the oscilloscope must be dc.

The PHASE SHIFT dial shifts the phase of the sweep and phase shift signals with respect to the signal output. Therefore, if the PHASE SHIFT dial reads 45-degree LEAD, the sweep and phase shift signals will be 45-degree LEAD with respect to the signal output. When testing systems as shown in figures 6-1, 6-2, and 6-3, the LEAD or LAG reading of the

PHASE SHIFT dial indicates lead or lag, respectively, in the system being tested. The choice of SWEEP or PHASE SHIFT signals for the horizontal axis depends upon the type of pattern preferred.

6.2.1 Unmodulated Signal

For Lissajous patterns in dc systems or any measurement not using carrier, the horizontal input of the oscilloscope is connected to the upper (unmod) PHASE SHIFT terminal. This signal is a sine wave of approximately 80 volts peak-to-peak, phase shifted from the SIGNAL output by the number of degrees set on the PHASE SHIFT dial.

6.2.2 Modulated Signal

For Lissajous patterns in ac systems or any measurements using carrier, the type of pattern may be any of three types.

a. Conventional 1:1 Lissajous, obtained when both axes are sine wave function (unmodulated).

b. Bow-tie, obtained when one axis is sine wave function and the other axis is modulated carrier.

c. Spoke-type, obtained when both axes are modulated carrier.

The pattern will therefore depend upon the type of sweep selected and whether the feedback signal is modulated or demodulated. In units having the SF-1 or SF-3 Special Function Modules, a modulated phase shift sweep is available at the PHASE SHIFT MOD terminal.

6.3 Waveform Selection

a. Sine

Phase and frequency response are obtained using SINE position.

b. Square

To observe system transient response, set WAVEFORM to SQUARE.

c. Peak Reference

PK position of WAVEFORM switch holds the signal at its peak value, whether modulated or unmodulated. This may be used to hold a mechanical system at any one position or to calibrate meter or oscilloscope levels.

d. Triangle

This waveform is available when Special Function Modules SF-1 or SF-2 are used. The main application of the triangle is to obtain a constant velocity signal. The velocity is determined by the function frequency.

e. Trapezoid

This waveform is available when Special Function Modules SF-1 or SF-2 are used. As with the triangle, a known velocity may be put into the system. However, by varying the slope of the trapezoid (SLOPE control), the velocity may be varied continuously at a fixed function frequency. This control, plus the flat peaks of the trapezoid, give a good picture of system overshoot at various velocities. For example, if the slope is adjusted to give a velocity equal to the maximum servo velocity, the closed-loop overshoot may be studied much more easily than with a square wave or triangle.

6.4 DC Servo Systems

Figure 6-1 shows a typical setup for making conventional tests on a DC servo system. In this application, no carrier is required, so the UNMOD-MOD switch is set to UNMOD. The oscilloscope pattern is shown at zero degrees, which is obtained by adjusting the PHASE SHIFT dial; the amount of lead or lag

in the system is then read directly on the dial. Phase and frequency response are obtained with the WAVEFORM switch set to the SINE position. The horizontal sweep may be obtained from SWEEP (linear) or PHASE SHIFT (sinusoidal), depending upon which oscilloscope pattern is preferred. To observe system transient response, set the WAVEFORM switch to SQUARE and connect the oscilloscope horizontal input to SWEEP. To hold the signal to peak positive value, set WAVEFORM to PK. For example, if AMPLITUDE is 30 volts peak-to-peak, switching to PK will give a dc output of +15 volts. If SF-1 or SF-2 modules are used, TRIANGLE and TRAPEZOID may be used. These are usually used with SWEEP (linear).

6.5 AC Servo Systems - Internal Carrier

Figure 6-2 shows a typical setup for an AC servo system, using the optional internal carrier module. The required test signal is a modulated suppressed carrier, which is obtained by setting the UNMOD-MOD switch to MOD. Power input (reference phase) to the servo is taken from the 16-watt carrier output(26 or 115V RMS) of the SERVODYNE. The CARRIER switch is set to the appropriate frequency (60 or 400 cps standard). Use DEVIATION CPS control if required. For phase measurements, use SINE waveform. See paragraph 6.2.2 concerning types of sweep and patterns. For square wave testing, connect the oscilloscope horizontal input to SWEEP and set WAVEFORM to SQUARE. To hold the carrier at peak value, set WAVEFORM to PK. For example, if AMPLITUDE is 30 volts peak-to-peak, switching to PK will give a constant carrier level of 30 volts peak-to-peak. If SF-1 or SF-2 modules are used, TRIANGLE and TRAPEZOID may be used. These are usually used with SWEEP (linear).

6.6 AC Servo Systems - External Carrier

Figure 6-3 shows a similar AC system, using external carrier. Operation is the same as internal carrier, except that the CARRIER CPS switch is set to EXT.

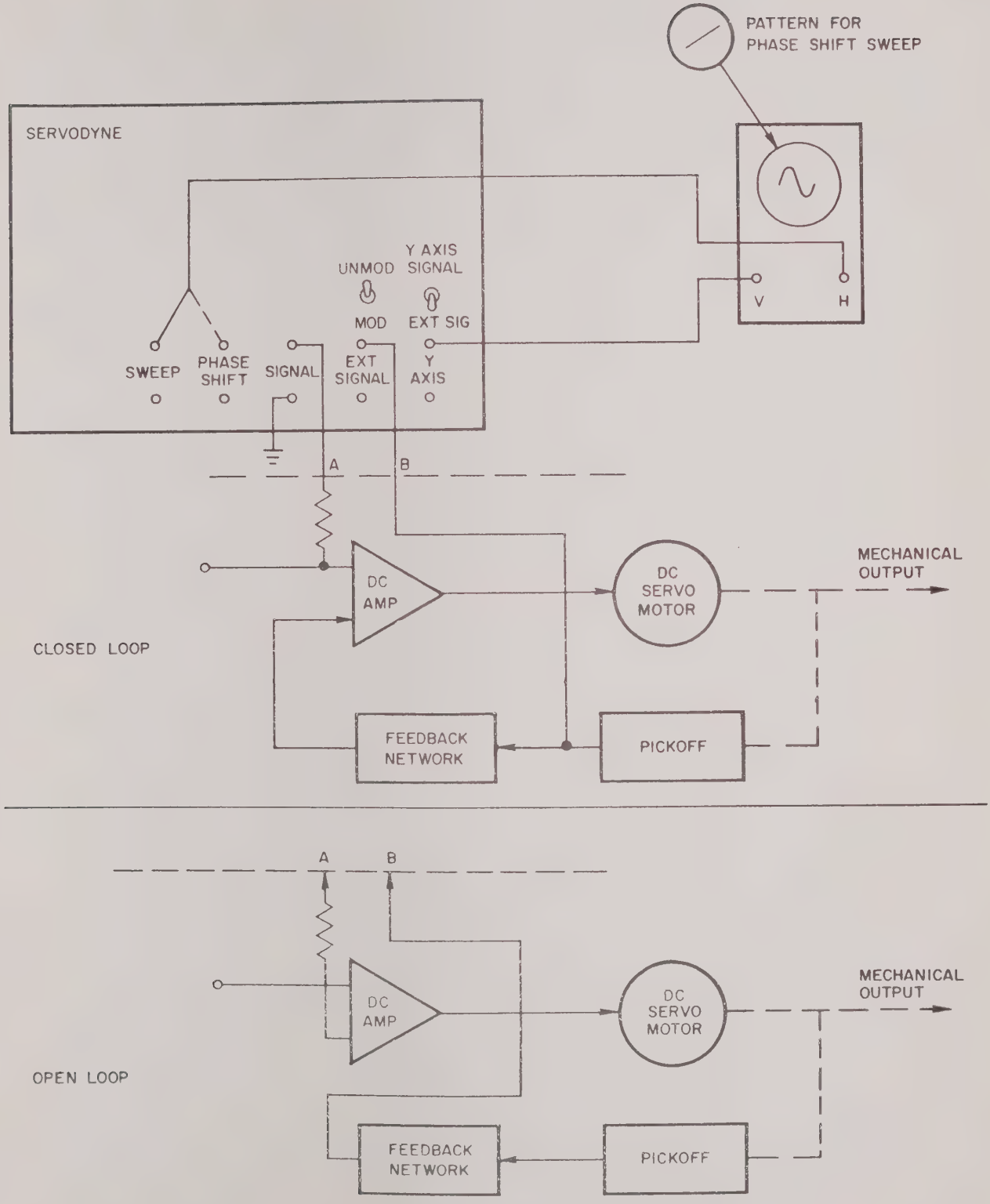


Figure 6-1. Typical Test Setups - DC Servo System

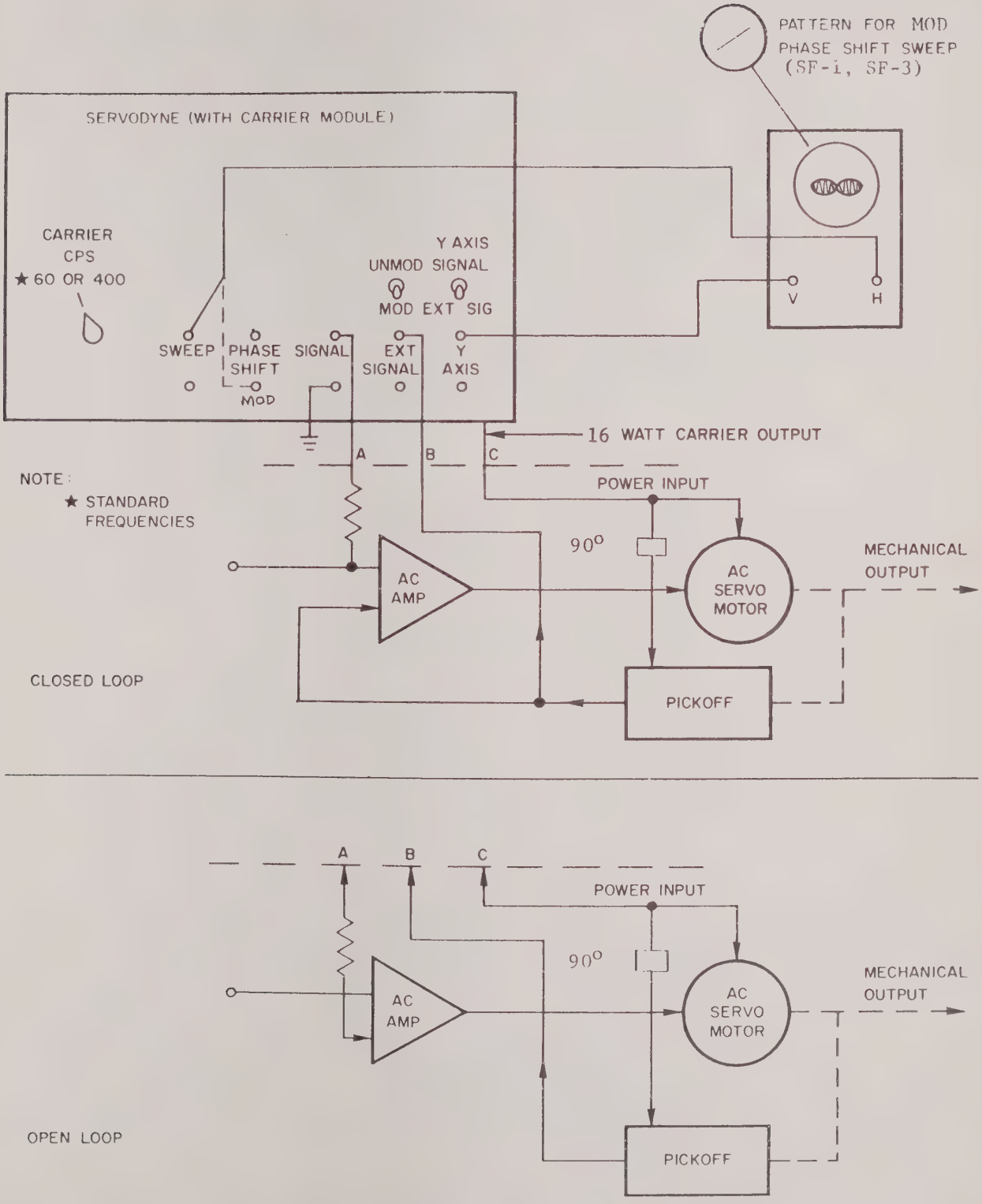


Figure 6-2. Typical Test Setups - AC Servo System (Internal Carrier)

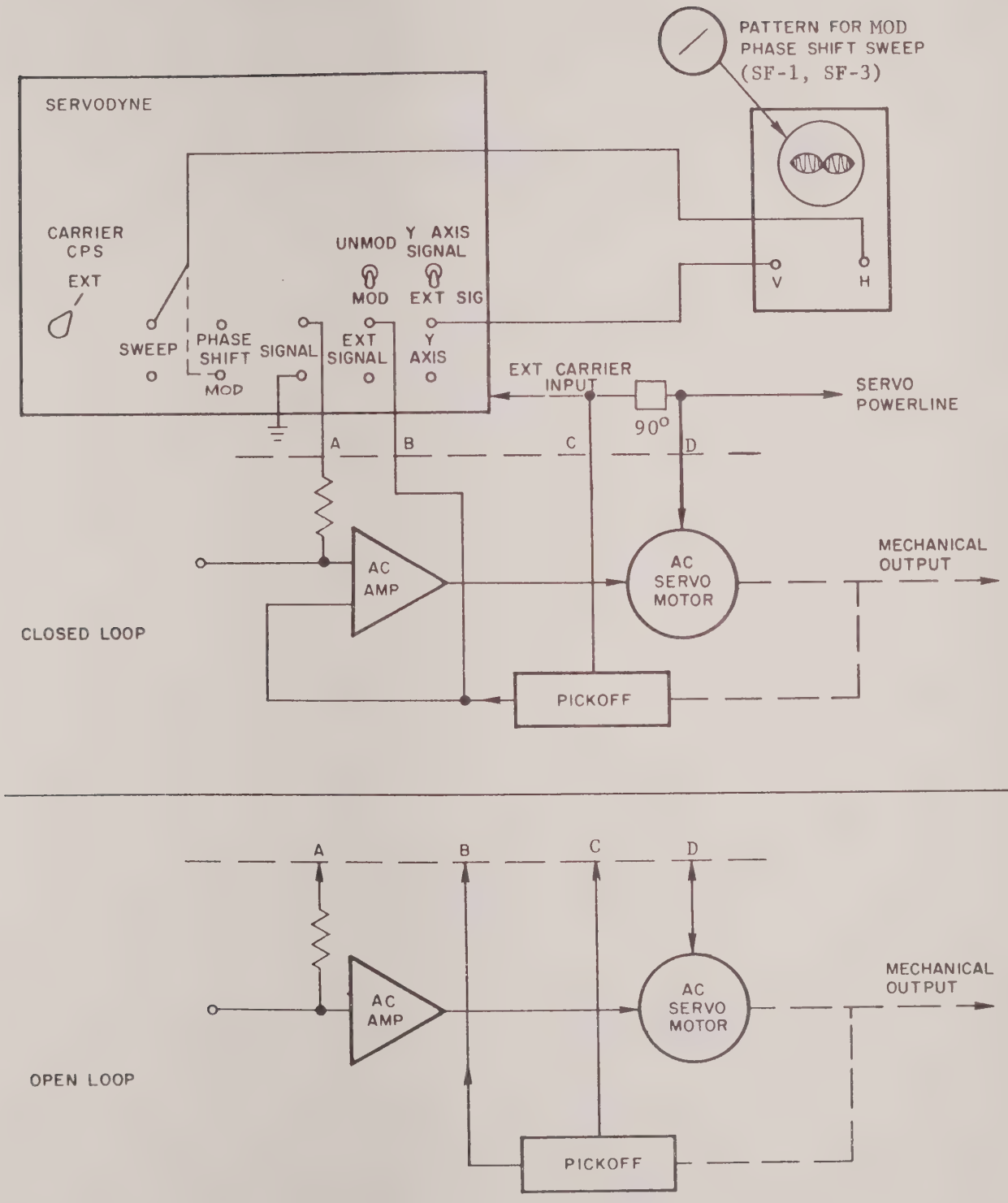


Figure 6-3. Typical Test Setups - AC Servo System (External Carrier)

7.0 MAINTENANCE

7.1 General

The only periodic maintenance required for the SERVODYNE unit is to keep the fan grill (rear of cabinet) clean. This grill is easily removed from the outside by prying the grill frame away from the cabinet.

Servicing consists of performing the adjustment procedures as needed, and troubleshooting in the event of part failure. The schematic diagrams are provided to be used in conjunction with standard troubleshooting techniques in the isolation of fault. In general, identification of the cause of malfunction of the equipment should begin with a check for proper operation of the power supply. Where loss of power is not responsible for the failure, the nature of the malfunction will indicate the module in which the trouble has occurred. The module can be removed from the cabinet, energized by means of the accessory interrupter cable, and tested.

7.2 Factory Service

Certain items in the SERVODYNE unit require factory service in the event of failure. Should the frequency or phase measurements indicate that the equipment is operating out of tolerance with the specifications the unit should be returned to the factory for repair. There are no provisions for field adjustment of the precision frequency dial mechanism in the 903A.

Similarly, replacement of capacitors in Extended Frequency Module EF-1 is best accomplished by returning the module to the factory.

7.3 Reference (Circuit Symbol) Designations

All reference designations conform to the MIL-STD 16B numbering method. Designations are broken down

according to mechanical assemblies and sub-assemblies. All designations consist of the unit number, sub-assembly number, if any, and the part designation. For example, resistor 1A2R10 is the tenth resistor, (R10), in the second sub-assembly, (A2), in the first unit, (1).

REMANCO

PARTS LIST

1805 COLORADO AVENUE • SANTA MONICA, CALIFORNIA

Wiring Diagram 501529

8.1 Chassis - Reference Designator Prefix 1

MODELS 902D, 902DK, 903A

REF. DESIG.	COMPONENT DESCRIPTION	MANUFACTURER	PART NO.
B1	Fan, Muffin 115V, 50/60 cps	Rotron	2053
C1	Capacitor, Mylar .05MF, 400V	Elpac	MD-1178
J1	Connector Blue Ribbon	Amphenol	26-4200-24S
J2	Connector Blue Ribbon	Amphenol	26-4200-24S
J3	Connector Blue Ribbon	Amphenol	26-4200-24S
J4	Connector Blue Ribbon	Amphenol	26-4200-24S
J5	Connector Blue Ribbon	Amphenol	26-4200-24S
J6	Connector Blue Ribbon	Amphenol	26-4200-24S
J7A	Connector Blue Ribbon	Amphenol	26-190-32
J7B	Connector Blue Ribbon	Amphenol	26-4200-32S
J7C	Connector Blue Ribbon	Amphenol	26-4200-24S
W1J1	Connector 2-Pole Flush	Amphenol	160-5
W2J1	Connector 2-Pole Flush	Amphenol	160-5

Wiring Diagram 501529

8.1 Chassis - Reference Designator Prefix 1 (cont'd)

MODELS 902D, 902DK, 903A

REF. DESIG.	COMPONENT DESCRIPTION	MANUFACTURER	PART NO.
W3J1	Connector 3-Pole Polarized	Amphenol	60-F
W4J1	Connector Blue Ribbon	Amphenol	26-4402-16P
W5J1	Connector Blue Ribbon	Amphenol	26-4401-24P
R1	Resistor, Variable 10K, 2W, 10%	Allen Bradley	JLU
R2	Resistor, Fixed Comp. 150K, 5%, 1W	Allen Bradley	RC32GF154J
R3	Resistor, Fixed Comp. 1K, 1/2W, 5%	Allen Bradley	RC20GF102J
R4	Resistor, Fixed Comp. 1K, 5%, 1/2W	Allen Bradley	RC20GF102J
R5	Resistor, Fixed Comp. 150K, 5%, 1W	Allen Bradley	RC32GF154J
T1	Transformer Filament	Remanco	10024
T2	Transformer Power	Remanco	10034
T3	Transformer External Carrier	Triad	F-16X

Wiring Diagram 502446

8.1.1 Chassis - Reference Designator Prefix 1
MODEL 902DSG

REF. DESIG.	COMPONENT DESCRIPTION	MANUFACTURER	PART NO.
B1	Fan, Muffin 115V, 50/60 cps	Rotron	2053
C1	Capacitor, Mylar .05 MF, 400V	Elpac	MD-1178
J1	Connector Blue Ribbon	Amphenol	26-4200-24S
J2	Connector Blue Ribbon	Amphenol	26-4200-24S
J3	Connector Blue Ribbon	Amphenol	26-4200-24S
J4	Connector Blue Ribbon	Amphenol	26-4200-24S
J5	Connector Blue Ribbon	Amphenol	26-4200-24S
J6	Connector Blue Ribbon	Amphenol	26-4200-24S
J7A	Connector Blue Ribbon	Amphenol	26-190-32
J7B	Connector Blue Ribbon	Amphenol	26-4200-32S
J7C	Connector Blue Ribbon	Amphenol	26-4200-24S
W1J1	Connector 2-Pole Flush	Amphenol	160-5
W2J1	Connector 2-Pole Flush	Amphenol	160-5

Wiring Diagram 502446

8.1.1 Chassis - Reference Designator Prefix 1 (cont'd)

MODEL 902DSG

REF. DESIG.	COMPONENT DESCRIPTION	MANUFACTURER	PART NO.
W3J1	Connector 3 Pole Polarized	Amphenol	60-F
W4J1	Connector Blue Ribbon	Amphenol	26-4402-16P
W5J1	Connector Blue Ribbon	Amphenol	26-4401-24P
W6J1	Connector Pygmy	Bendix	PT02A-22 21SX
W7J1	Connector Pygmy	Bendix	PT02A-22-21S
R1	Resistor, Variable 10K, 2W, 10%	Allen Bradley	JLU
R2	Resistor, Fixed Comp. 150K, 5%, 1W	Allen Bradley	RC32GF154J
R3	Resistor, Fixed Comp. 1K, 1/2W, 5%	Allen Bradley	RC20GF102J
R4	Resistor, Fixed Comp. 1K, 5%, 1/2W	Allen Bradley	RC20GF102J
R5	Resistor, Fixed Comp. 150K, 5%, 1W	Allen Bradley	RC32GF154J
T1	Transformer Filament	Remanco	10024
T2	Transformer Power	Remanco	10034
T3	Transformer External Carrier	Triad	F-16X

8.2 Carrier Module (Regulated) - Reference Designator Prefix 1A1

REF. DESIG.	COMPONENT DESCRIPTION	MANUFACTURER	PART NO.
C4	Capacitor, Paper Metal Case, 0.01MFD, 600V	Sprague	CP09A1 KF103M
C5	Capacitor, Mylar .05MFD, 400V	ELPAC	MD1178
C6	Capacitor, Mylar .05 MFD, 400V	ELPAC	MD1178
C7	Capacitor, Mylar 1.0 MFD, 300V	ELPAC	ZD3A-105
C8	Capacitor, Mylar 1.0 MFD, 300V	ELPAC	ZD3A-105
C10	Capacitor, Electrolytic 100MFD, 50V	Sprague	TVA-1310
C11	Capacitor, Mylar 0.5 MFD, 300V	ELPAC	MD1732
C12	Capacitor, Mylar 0.5 MFD, 300V	ELPAC	MD1732
C13	Capacitor, Mylar 1.0 MFD, 300V	ELPAC	ZD3A-105
C14	Capacitor, Electrolytic 40MFD,450V	Sprague	TVA-1712
C15	Capacitor, Electrolytic 40 MFD, 450V	Sprague	TVA-1712
C16	Capacitor, Cer Disc .003 MFD, 1KV	Elmenco	CCD-302
C17	Capacitor, Mylar 1 MFD, 300V	ELPAC	VX-1822
C18	Capacitor, Mylar .05 MFD, 200V	ELPAC	C-5002

8.2 Carrier Module (Regulated) - Reference Designator Prefix 1A1 (cont'd)

REF. DESIG.	COMPONENT DESCRIPTION	MANUFACTURER	PART NO.
C19	Capacitor, Cer Disc .005 MFD, 1KV	Elmenco	CCD-502
C20	Capacitor, Cer Disc 15 PF, 1KV	Elmenco	CCD-150
C21	Capacitor, Mica 50PF, 500V	Elmenco	CM15E500J
C22	Capacitor, Mica 200PF, 500V	Elmenco	CM20D201J
C23	Capacitor, Mylar .05 MFD, 400V	ELPAC	MD1178
C24	Capacitor, Mylar .5 MFD, 300V	ELPAC	MD1732
CR1	Diode, Zener 48.5V ± 5%, 500MW	PSI	PS-6322A
CR2	Diode, Zener 48.5V ±5% 500MW	PSI	PS-6322A'
CR3	Diode	PSI	1N485
CR6	Diode	PSI	1N485
CR7	Diode, Zener 20V, 400MW	Motorola	1N968B
P1	Connector, Blue Ribbon	Amphenol	26-4100-24P
R3	Resistor, Composition 12K, ±5%, 1/2W	Allen Bradley	EB
R5	Resistor, Composition 47K ±5%, 2W	Allen Bradley	HB
R6	Resistor, Composition 47 ohms, ±5%, 1/2W	Allen Bradley	EB

8.2 Carrier Module (Regulated) - Reference Designator Prefix 1A1 (cont'd)

REF. DESIG.	COMPONENT DESCRIPTION	MANUFACTURER	PART NO.
R9	Resistor, Composition, 22K, ±5%, 1W	Allen Bradley	GB
R10	Resistor, Composition, 22K, ±5%, 1W	Allen Bradley	GB
R11	Resistor, Composition, 1 Meg., ±5%, 1/2W	Allen Bradley	EB
R12	Resistor, Composition, 1 Meg., ±5%, 1/2W	Allen Bradley	EB
R13	Resistor, Composition, 560 ohms, ±5%,1/2W	Allen Bradley	EB
R14	Resistor, Composition, 47K, ±5%, 2W	Allen Bradley	HB
R15	Resistor, Composition, 47K, ±5%, 2W	Allen Bradley	HB
R16	Resistor, Composition, 1K, ±5%, 1/2W	Allen Bradley	EB
R17	Resistor, Composition, 100K, ±5%, 1/2W	Allen Bradley	EB
R18	Resistor, Composition, 100K, ±5%, 1/2W	Allen Bradley	EB
R19	Resistor, Composition, 1K, ±5%, 1/2W	Allen Bradley	EB
R20	Resistor, 300 ohms, ±5%, 10W	Clarostat	VPR10F
R22	Resistor, Composition, 1 Meg., ±5%, 1/2W	Allen Bradley	EB

8.2 Carrier Module (Regulated) - Reference Designator Prefix 1A1 (cont'd)

REF. DESIG.	COMPONENT DESCRIPTION	MANUFACTURER	PART NO.
R23	Resistor, Composition, 120K, ±5%, 2W	Allen Bradley	HB
R24	Resistor, Carbon, 24K, ±1%, 1/2W	I.R.C.	RN20X-DCC-243F
R25	Resistor, Composition, 120K, ±5%, 2W	Allen Bradley	HB
R26	Resistor, Carbon, 24K, ±1%, 1/2W	I.R.C.	RN20X-DCC-243F
R27	Resistor, Composition, 120K, ±5%, 2W	Allen Bradley	HB
R28	Resistor, Composition, 1 Meg., ±5%, 1/2W	Allen Bradley	EB
R29	Resistor, Composition, 150K, ±5%, 1/2W	Allen Bradley	EB
R30	Resistor, Composition, 5.6K, ±5%, 1/2W	Allen Bradley	EB
R31	Resistor, Composition, 100K, ±5%, 1/2W	Allen Bradley	EB
R32	Resistor, Composition, 100K, ±5%, 1/2W	Allen Bradley	EB
R33	Resistor, Met. Film 15K, 1/4W, 1%	I.R.C.	CEB-TO-15K-1%
R34	Resistor, Variable Comp. 10K, 2W, 10%	Allen Bradley	JLU-1031
R35	Resistor, Met. Film 267K, 1/2W, 1%	I.R.C.	CEC-TO-267K-1%
R36	Resistor, Met. Film 562K, 1/4W, 1%	I.R.C.	CEB-TO-562K-1%

8.2 Carrier Module (Regulated) - Reference Designator Prefix 1A1 (cont'd)

REF. DESIG.	COMPONENT DESCRIPTION	MANUFACTURER	PART NO.
R37	Resistor, Met. Film 1M, 1/4W, 1%	I.R.C.	CEB-TO-1M-1%
R38	Resistor, Fixed Comp 22K, 1/2W, 5%	Allen Bradley	EB
R39	Resistor, Fixed Comp 220K, 1/2W, 5%	Allen Bradley	EB
R40	Resistor, Fixed Comp 150K, 1W, 5%	Allen Bradley	GB
R41	Resistor, Fixed Comp 150K, 1/2W, 5%	Allen Bradley	EB
R42	Resistor, Fixed Comp 470K, 1/2W, 5%	Allen Bradley	EB
R43	Resistor, Fixed Comp 2.2K, 1/2W, 5%	Allen Bradley	EB
R44	Resistor, Fixed Comp 470K, 1/2W, 5%	Allen Bradley	EB
R45	Resistor, Fixed Comp 1K, 1/2W, 5%	Allen Bradley	EB
R46	Resistor, Fixed Comp 1 Meg, 1/2W, 5%	Allen Bradley	EB
R47	Resistor, Fixed Comp 68K, 1/2W, 5%	Allen Bradley	EB
R48	Resistor, Fixed Comp 150K, 1/2W, 5%	Allen Bradley	EB
R49	Resistor, Fixed Comp 1.3 Meg, 1/2W, 5%	Allen Bradley	EB
R50	Resistor, Fixed Comp 100K, 2W, 5%	Allen Bradley	HB

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8.2 Carrier Module (Regulated) - Reference Designator Prefix 1A1 (cont'd)

REF. DESIG.	COMPONENT DESCRIPTION	MANUFACTURER	PART NO.
R51	Resisistor, Fixed Comp 2.4 Meg., 1/2W, 5%	Allen Bradley	EB
R52	Resistor, Fixed Comp 680K, 1/2W, 5%	Allen Bradley	EB
R53	Resistor, Fixed Comp 180K, 1/2W, 5%	Allen Bradley	EB
R54	Resistor, Fixed Comp 27K, 2W, 5%	Allen Bradley	HB
R55	Resistor, Fixed Comp 100K, 1/2W, 5%	Allen Bradley	EB
R56	Resistor, Fixed Comp 20K, 1/2W, 5%	Allen Bradley	EB
R57	Resistor, Fixed Comp 1.5K, 1/2W, 5%	Allen Bradley	EB
R58	Resistor, Fixed Comp 1 Meg, 1/2W, 5%	Allen Bradley	EB
R59	Resistor, Fixed Comp 100K, 1/2W, 5%	Allen Bradley	EB
R60	Resistor, Fixed Comp 1 Meg, 1/2W, 5%	Allen Bradley	EB
R61	Resistor, Fixed Comp 180K, 1/2W, 5%	Allen Bradley	EB
R62	Resistor, Fixed W.W. 3.3K, 5%, 10W	Sprague	247E3325
T1	Transformer, Output	Remanco	10023
T2	Transformer, Regulator	Remanco	10042
V1	Tube, Electron		12AU7
V2	Tube, Electron		12AU7

8.2 Carrier Module (Regulated) - Reference Designator Prefix 1A1 (cont'd)

REF. DESIG.	COMPONENT DESCRIPTION	MANUFACTURER	PART NO.
V3	Tube, Electron		5881
V4	Tube, Electron		5881
V5	Tube, Electron		12AT7
V6	Tube, Electron		6U8A
V7	Tube, Electron		12AX7
V8	Tube, Electron		6AN8A
V9	Tube, Electron		12AU7

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8.3 Low Frequency Oscillator Module - Reference Designator Prefix 1A2

REF. DESIG.	COMPONENT DESCRIPTION	MANUFACTURER	PART NO.
C1	Capacitor, Cer Disc 15 PF	Centralab	DD-150
C2	Capacitor, Cer Disc 15 PF	Centralab	DD-150
C3	Capacitor, Cer Disc .003 MF	Elmenco	CCD-302
C4	Capacitor, Cer Disc 15 PF	Centralab	DD-150
C5	Capacitor, Cer Disc 15 PF	Centralab	DD-150
C6	Capacitor, Cer Disc .003 MF	Elmenco	CCD-302
C7	Capacitor, Cer Disc 15 PF	Centralab	DD-150
C8	Capacitor, Cer Disc 15 PF	Centralab	DD-150
C9	Capacitor, Cer Disc 15 PF	Centralab	DD-150
C10	Capacitor, Cer Disc 15 PF	Centralab	DD-150
C11	Capacitor, Cer Disc 15 PF	Centralab	DD-150
C12	Capacitor, Sil Mica 100 PF 500V	Elmenco	CM15E101
C13	Capacitor, Cer Disc..003 MF	Elmenco	CCD-302
C14	Capacitor, Mylar .1 MF 300V	Elpac	MD1177
C15	Capacitor, Cer Disc .003 MF	Elmenco	CCD-302
C16	Capacitor, Cer Disc .003 MF	Elmenco	CCD-302
C17	Capacitor, Cer Disc .003 MF	Elmenco	CCD-302
C18	Capacitor, Cer Disc 15 PF	Centralab	DD-150
C19	Capacitor, Cer Disc 15 PF	Centralab	DD-150
C20	Capacitor, Cer Disc 15 PF	Centralab	DD-150

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8.3 Low Frequency Oscillator Module - Reference Designator Prefix 1A2 (cont'd)

REF. DESIG.	COMPONENT DESCRIPTION	MANUFACTURER	PART NO.
C21	Capacitor, Cer Disc .003	Elmenco	CCD-302
C22	Capacitor, Cer Disc .003	Elmenco	CCD-302
C23	Capacitor, Cer Disc 15 PF	Centralab	DD-150
C24	Capacitor, Cer Disc 15 PF	Centralab	DD-150
C25	Capacitor, Cer Disc .003	Elmenco	CCD-302
CR1	Diode, Zener 48.5V ± 5% 500MW	PSI	PS-6322A
CR2	Diode, Zener 48.5V ± 5%, 500MW	PSI	PS-6322A
P1	Connector, Blue Ribbon	Amphenol	26-4100-24P
R1	Resistor, Fixed WW 100K 1%, 1/2W	PRC	PRC-50AP
R2	Resistor, Fixed WW 100K 1%, 1/2W	PRC	PRC-50AP
R3	Resistor, Fixed Comp 390K 1/2W 5%	AB	RC20GF394J
R4	Resistor, fixed Comp 300K 1/2W 5%	AB	RC20GF304J
R5	Resistor, Fixed Comp 300K 1/2W 5%	AB	RC20GF304J
R6	Resistor, Fixed Comp 1M 1/2W 5%	AB	RC20GF105J
R7	Resistor, Fixed Comp 360K 1/2W 5%	AB	RC20GF364J
R8	Resistor, Fixed Comp 470K 1/2W 5%	AB	RC20GF474J

8.3 Low Frequency Oscillator Module - Reference Designator Prefix 1A2 (cont'd)

REF. DESIG.	COMPONENT DESCRIPTION	MANUFACTURER	PART NO.
R9	Resistor, Fixed Comp 47K, 1/2W 5%	AB	RC20GF473J
R10	Resistor, Fixed Comp 1M 1/2W 5%	AB	RC20GF105J
R11	Resistor, Fixed Comp 360K 1/2W 5%	AB	RC20GF364J
R12	Resistor, Fixed WW 30K 5W 5%	Sprague	243E 3035
R13	Resistor, Fixed WW 5K 5W 5%	Sprague	243E 5025
R14	Resistor, Fixed WW 100K 1%, 1/2W	PRC	PRC-50AP
R15	Resistor, Fixed WW 100K 1% , 1/2W	PRC	PRC-50AP
R16	Resistor, Fixed Comp 390K 1/2W 5%	AB	RC20GF394J
R17	Resistor, Fixed Comp 300K 1/2W 5%	AB	RC20GF304J
R18	Resistor, Fixed Comp 300K 1/2W 5%	AB	RC20GF304J
R19	Resistor, Fixed Comp 1M 1/2W 5%	AB	RC20GF105J
R20	Resistor, Fixed Comp 360K 1/2W 5%	AB	RC20GF364J
R21	Resistor, Fixed Comp 470K 1/2W 5%	AB	RC20GF474J
R22	Resistor, Fixed Comp 47K 1/2W 5%	AB	RC20GF473J

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8.3 Low Frequency Oscillator Module - Reference Designator Prefix 1A2 (cont'd)

REF. DESIG.	COMPONENT DESCRIPTION	MANUFACTURER	PART NO.
R23	Resistor, Fixed Comp 1M 1/2W 5%	AB	RC20GF105J
R24	Resistor, Fixed Comp 360K 1/2W 5%	AB	RC20GF364J
R25	Resistor, Fixed WW 30K 5W 5%	Sprague	243E 3035
R26	Resistor, Fixed Ww 5K 5W 5%	Sprague	243E 5025
R27	Resistor, Fixed WW 5K 5W 5%	Sprague	243E 5025
R28	Resistor, Fixed WW 5K 5W 5%	Sprague	243E 5025
R29	Resistor, Fixed Comp 300K 1/2W 5%	AB	RC20GF304J'
R30	Resistor, Fixed Comp 300K 1/2W 5%	AB	RC20GF304J
R31	Resistor, Fixed Comp 390K 1/2W 5%	AB	RC20GF394J
R32	Resistor, Fixed Comp 1M 1/2W 5%	AB	RC20GF105J
R33	Resistor, Fixed Comp 360K 1/2W 5%	AB	RC20GF364J
R34	Resistor, Fixed Comp 470K 1/2W 5%	AB	RC20GF474J
R35	Resistor, Fixed Comp 47K 1/2W 5%	AB	RC20GF473J
R36	Resistor, fixed Comp 1M, 1/2W, 5%	AB	RC20GF105J

8.3 Low Frequency Oscillator Module - Reference Designator Prefix 1A2 (cont'd)

REF. DESIG.	COMPONENT DESCRIPTION	MANUFACTURER	PART NO.
R37	Resistor, Fixed Comp 360K 1/2W 5%	AB	RC20GF364J
R38	Resistor, Fixed WW 30K 5W 5%	Sprague	243E 3035
R39	Resistor, Fixed Comp 1K 1/2W 5%	AB	RC20GF102J
R40	Resistor, Var Comp 10K 2W 10%	AB	JLU-1031
R41	Resistor, Var Comp 10K 2W 10%	AB	JLU-1031
R42	Resistor, Fixed Comp 150K 1W 5%	AB	RC32GF154J
R43	Resistor, Fixed Comp 1K 1/2W 5%	AB	RC20GF102J
R44	Resistor, Fixed Comp 1K 1/2W 5%	AB	RC20GF102J
R45	Resistor, Fixed Comp 150K 1W 5%	AB	RC32GF154J
R46	Resistor, Fixed WW 100K 1%, 1/2W	PRC	PRC-50AP
R47	Resistor, Fixed WW 200K 1%, 1/2W	PRC	PRC-50AP
R48	Resistor, Dep. Carb. 300K 1/2W 1%	IRC	RN20X-DCC-3003F
R49	Resistor, Dep. Carb. 300K 1/2W 1%	IRC	RN20X-DCC-3003F

8.3 Low Frequency Oscillator Module - Reference Designator Prefix 1A2 (cont'd)

REF. DESIG.	COMPONENT DESCRIPTION	MANUFACTURER	PART NO.
R50	Resistor, Fixed Comp 390K 1/2W 5%	AB	RC20GF394J
R51	Resistor, Dep. Carb. 1M 1/2W 1%	IRC	RN20X-DCC-1004F
R52	Resistor, Dep. Carb. 360K 1/2W 1%	IRC	RN20X-DCC-3603F
R53	Resistor, Fixed Comp 470K 1/2W 5%	AB	RC20GF474J
R54	Resistor, Fixed Comp 47K 1/2W 5%	AB	RC20GF473J
R55	Resistor, Dep. Carb. 1M 1/2W 1%	IRC	RN20X-DCC-1004F
R56	Resistor, Dep. Carb. 360K 1/2W 1%	IRC	RN20X-DCC-3603F
R57	Resistor, Fixed WW 25K 5W 5%	Sprague	243E2535
R58	Resistor, Fixed Comp 1K 1/2W 5%	AB	RC20GF102J
R59	Resistor, Fixed WW 100K 1%, 1/2W	PRC	PRC-50AP
R60	Resistor, Fixed WW 200K 1%, 1/2W	PRC	PRC-50AP
R61	Resistor, Fixed Comp 390K 1/2W 5%	AB	RC20GF394J
R62	Resistor, Dep. Carb. 300K 1/2W 1%	IRC	RN20X-DCC-3003F
R63	Resistor, Dep. Carb. 300K 1/2W 1%	IRC	RN20X-DCC-3003F

8.3 Low Frequency Oscillator Module - Reference Designator Prefix 1A2 (cont'd)

REF. DESIG.	COMPONENT DESCRIPTION	MANUFACTURER	PART NO.
R64	Resistor, Dep. Carb. 1M 1/2W 1%	IRC	RN20X-DCC-1004F
R65	Resistor, Dep. Carb. 360K 1/2W 1%	IRC	RN20X-DCC-3603F
R66	Resistor, Fixed Comp 47K 1/2W 5%	AB	RC20GF473J
R67	Resistor, Fixed Comp 470K 1/2W 5%	AB	RC20GF474J
R68	Resistor, Dep. Carb. 1M 1/2W 1%	IRC	RN20X-DCC-1004F
R69	Resistor, Dep. Carb. 360K 1/2W 1%	IRC	RN20X-DCC-3603F
R70	Resistor, Fixed WW 25K 5W 5%	Sprague	243E 2535
R71	Resistor, Fixed Comp 3.9K 2W 5%	AB	RC42GF392J
R72	Resistor, Fixed WW 100K 1%, 1/2W	PRC	PRC-50AP
R73	Resistor, Fixed WW 100K 1% , 1/2W	PRC	PRC-50AP
R74	Resistor, Fixed Comp 3.9K 2W 5%	AB	RC42GF392J
R75	Resistor, Fixed Comp 390K 1/2W 5%	AB	RC20GF394J
R76	Resistor, Fixed WW 300K 1/2W 5%	AB	RC20GF304J
R77	Resistor, Fixed Comp 300K 1/2W 5%	AB	RC20GF304J

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8.3 Low Frequency Oscillator Module - Reference Designator Prefix 1A2

REF. DESIG.	COMPONENT DESCRIPTION	MANUFACTURER	PART NO.
R78	Resistor, Fixed Comp 1M 1/2W 5%	AB	RC20GF105J
R79	Resistor, Fixed Comp 360K 1/2W 5%	AB	RC20GF364J
R80	Resistor, Fixed Comp 47K 1/2W 5%	AB	RC20GF473J
R81	Resistor, Fixed Comp 470K 1/2W 5%	AB	RC20GF474J
R82	Resistor, Fixed Comp 1M 1/2W 5%	AB	RC20GF105J
R83	Resistor, Fixed Comp 360K 1/2W 5%	AB	RC20GF364J
R84	Resistor, Fixed WW 25K 5W 5%	Sprague	243E 2535
R85	Resistor, Fixed WW 5K 5W 5%	Sprague	243E 5025
R86	Resistor, Var. Comp 10K 2W 10%	AB	JLU-1031
R87	Resistor, Fixed Comp 1K 1/2W 5%	AB	RC20GF102J
R88	Resistor, Fixed Comp 100K 2W 5%	AB	RC42GF104J
R89	Resistor, Fixed Comp 1M 1/2W 5%	AB	RC20GF105J
R90	Resistor, Fixed Comp 5.1K 1/2W 5%	AB	RC20GF512J

8.3 Low Frequency Oscillator Module - Reference Designator Prefix 1A2

REF. DESIG.	COMPONENT DESCRIPTION	MANUFACTURER	PART NO.
R91	Resistor, Fixed Comp 5.1K 1/2W 5%	AB	RC20GF512J
R92	Resistor, Fixed Comp 1M 1/2W 5%	AB	RC20GF105J
R93	Resistor, Fixed WW 12K 5W 5%	Sprague	243E 1235
R94	Resistor, Var Comp 25K 2W 10%	AB	JLU-2531
V1	Tube		12AX7
V2	Tube		12AX7
V3	Tube		5687
V4	Tube		12AX7
V5	Tube		12AX7
V6	Tube		12AX7
V7	Tube		12AX7
V8	Tube		5687
V9	Tube		12AX7
V10	Tube		12AX7
V11	Tube		6072
V12	Tube		12AX7
V13	Tube		5687
V14	Tube		6072
V15	Tube		12AX7
V16	Tube		12AU7

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8.4 Sweep & Modulator Module - Reference Designator Prefix 1A3

REF. DESIG.	COMPONENT DESCRIPTION	MANUFACTURER	PART NO.
A1	Modulator M-2B	Remanco	501692B
A2	Blocking Osc	Remanco	501578B
C2	Capacitor, Cer Disc 15PF 1KV	Elmenco	CCD-150
C5	Capacitor, Cer Disc 15PF 1KV	Elmenco	CCD-150
C6	Capacitor, Sil Mica 330PF 500V	Elmenco	CM-15E-331J
C7	Capacitor, Sil Mica 39PF 500V	Elmenco	CM-15E-390J
C8	Capacitor, Sil Mica 100PF 500V	Elmenco	CM-15E-101J
C9	Capacitor, Cer Disc .003MF 1KV	Elmenco	CCD-302
C10	Capacitor, Sil Mica 68PF 500V	Elmenco	CM-15E-680J
C11	Capacitor, Cer Disc 15PF 1KV	Elmenco	CCD-150
C19	Capacitor, Cer Disc 15PF 1KV	Elmenco	CCD-150
C20	Capacitor, Cer Disc .003MF 1KV	Elmenco	CCD-302
C21	Capacitor, Sil Mica 5PF 500V	Elmenco	CM-15E-050J
C22	Capacitor, Cer Disc .005MF 1KV	Elmenco	CCD-502
C23	Capacitor, Cer Disc .005MF 1KV	Elmenco	CCD-502

8.4 Sweep & Modulator Module - Reference Designator Prefix 1A3 (cont'd)

REF. DESIG.	COMPONENT DESCRIPTION	MANUFACTURER	PART NO.
C24	Capacitor, Cer Disc .005MF 1KV	Elmenco	CCD-502
C25	Capacitor, Cer Disc .005MF 1KV	Elmenco	CCD-502
C26	Capacitor, Cer Disc .003MF 1KV	Elmenco	CCD-302
C27	Capacitor, Cer Disc 15PF 1KV	Elmenco	CCD-150
C28	Capacitor, Cer Disc 15PF 1KV	Elmenco	CCD-150
C29	Capacitor, Sil Mica 510PF 300V	Elmenco	CM-15E-511J
C30	Capacitor, Sil Mica 100PF 50CV	Elmenco	CM-15E-101J
C31	Capacitor, Cer Disc 15PF 1KV	Elmenco	CCD-150
C32	Capacitor, Sil Mica 2PF 500V	Elmenco	CM-15E-020J
C33	Capacitor, Sil Mica 2PF 500V	Elmenco	CM-15E-020J
C34	Capacitor, Cer Disc .005MF 1KV	Elmenco	CCD-502
C35	Capacitor, Cer Disc. .003 MF 1KV	Elmenco	CCD-302
C36	Capacitor, Sil Mica 10 PF 500V	Elmenco	CM-15E-100J
C37	Capacitor, Cer Disc 15PF 1KV	Elmenco	CCD-150

8.4 Sweep & Modulator Module - Reference Designator Prefix 1A3 (cont'd)

REF. DESIG.	COMPONENT DESCRIPTION	MANUFACTURER	PART NO.
CR3	Diode, Gen. Purpose	Hoffman	HB6
CR4	Diode, Gen. Purpose	Hoffman	HB6
CR8	Diode, Silicon 4 Layer 20V	Shockley	4E20M-8
CR9	Diode, Germanium		1N34A
P1	Connector, Blue Ribbon	Amphenol	26-4100-24P
R1	Resistor, Fixed Comp 100K 5% 1/2W	Allen Bradley	RC20GF104J
R2	Resistor, Fixed Comp 22 Meg 5% 1/2W	Allen Bradley	RC20GF226J
R3	Resistor, Fixed Comp 150K 5% 1/2W	Allen Bradley	RC20GF154J
R4	Resistor, Fixed Comp 150K 5% 1W	Allen Bradley	RC32GF154J
R5	Resistor, Fixed Comp 3.9K 5% 1/2W	Allen Bradley	RC20GF392J
R6	Resistor, Fixed Comp 100K 5% 1/2W	Allen Bradley	RC20GF104J
R7	Resistor, Fixed Comp 470K 5% 1/2W	Allen Bradley	RC20GF474J
R8	Resistor, Fixed Comp 1 Meg 5% 1/2W	Allen Bradley	RC20GF105J
R9	Resistor, Fixed Comp 150K 5% 1/2W	Allen Bradley	RC20GF154J
R10	Resistor, Fixed Comp 2.4 Meg 5% 1/2W	Allen Bradley	RC20GF245J
R11	Resistor, Fixed Comp 180K 5% 1/2W	Allen Bradley	RC20GF184J

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8.4 Sweep & Modulator Module - Reference Designator Prefix 1A3 (cont'd)

REF. DESIG.	COMPONENT DESCRIPTION	MANUFACTURER	PART NO.
R12	Resistor, Fixed Comp 68K 5% 1/2W	Allen Bradley	RC20GF683J
R13	Resistor, Fixed Comp 100K 5% 2W	Allen Bradley	RC42GF104J
R14	Resistor, Fixed Comp 1.3 Meg 5% 1/2W	Allen Bradley	RC20GF135J
R15	Resistor, Fixed Comp 68K 5% 1/2W	Allen Bradley	RC20GF683J
R16	Resistor, Fixed Comp 22 Meg 5% 1/2W	Allen Bradley	RC20GF226J
R17	Resistor, Fixed Comp 150K 5% 1/2W	Allen Bradley	RC20GF154J
R18	Resistor, Fixed Comp 150K 5% 1W	Allen Bradley	RC32GF154J
R19	Resistor, Fixed Comp 3.9K 5% 1/2W	Allen Bradley	RC20GF392J
R20	Resistor, Fixed Comp 100K 5% 1/2W	Allen Bradley	RC20GF104J
R21	Resistor, Fixed Comp 470K 5% 1/2W	Allen Bradley	RC20GF474J
R22	Resistor, Fixed Comp 1 Meg 5% 1/2W	Allen Bradley	RC20GF105J
R23	Resistor, Fixed Comp 150K 5% 1/2W	Allen Bradley	RC20GF154J
R24	Resistor, Fixed Comp 100K 5% 2W	Allen Bradley	RC42GF104J

8.4 Sweep & Modulator Module - Reference Designator Prefix 1A3 (cont'd)

REF. DESIG.	COMPONENT DESCRIPTION	MANUFACTURER	PART NO.
R25	Resistor, Fixed Comp 180K 5% 1/2W	Allen Bradley	RC20GF184J
R26	Resistor, Fixed Comp 68K 5% 1/2W	Allen Bradley	RC20GF683J
R27	Resistor, Fixed Comp 100K, 5%, 2W	Allen Bradley	RC42GF104J
R34	Resistor, Fixed WW 400K 1% 1/2W	Pacific Resistor	50AP
R35	Resistor, Fixed WW 400K 1% 1/2W	Pacific Resistor	50AP
R36	Resistor, Fixed Comp 390K 5% 1/2W	Allen Bradley	RC20GF394J
R37	Resistor, Fixed Comp 150K 5% 1/2W	Allen Bradley	RC20GF154J
R38	Resistor, Fixed Comp 150K 5% 1W	Allen Bradley	RC32GF154J
R39	Resistor, Fixed Comp 470K 5% 1/2W	Allen Bradley	RC20GF474J
R40	Resistor, Fixed Comp 1 Meg 5% 1/2W	Allen Bradley	RC20GF105J
R41	Resistor, Fixed Comp 150K 5% 1/2W	Allen Bradley	RC20GF154J
R42	Resistor, Var Comp 10K Pot 2W, 10%	Allen Bradley	JLU-1031
R43	Resistor, Fixed Comp 180K 5% 1/2W	Allen Bradley	RC20GF184J
R44	Resistor, Fixed Comp 68K 5% 1/2W	Allen Bradley	RC20GF683J

8.4 Sweep & Modulator Module - Reference Designator Prefix 1A3 (cont'd)

REF. DESIG.	COMPONENT DESCRIPTION	MANUFACTURER	PART NO.
R45	Resistor, Fixed Comp 100K 5% 2W	Allen Bradley	RC42GF104J
R46	Resistor, Fixed Comp 1.3M 5% 1/2W	Allen Bradley	RC20GF135J
R47	Resistor, Fixed Comp 2.4M 5% 1/2W	Allen Bradley	RC20GF245J
R50	Resistor, Fixed Comp 150K 5% 1/2W	Allen Bradley	RC20GF154J
R51	Resistor, Fixed Comp 150K 5% 1W	Allen Bradley	RC32GF154J
R52	Resistor, Fixed Comp 470K 5% 1/2W	Allen Bradley	RC20GF474J
R53	Resistor, Fixed Comp 1 Meg 5% 1/2W	Allen Bradley	RC20GF105J
R54	Resistor, Fixed Comp 150K 5% 1/2W	Allen Bradley	RC20GF154J
R56	Resistor, Fixed Comp 180K 5% 1/2W	Allen Bradley	RC20GF184J
R57	Resistor, Fixed Comp 68K 5% 1/2W	Allen Bradley	RC20GF683J
R58	Resistor, Fixed comp 100K 5% 2W	Allen Bradley	RC42GF104J
R59	Resistor, Fixed Comp 1.3 Meg 5% 1/2W	Allen Bradley	RC20GF135J
R60	Resistor, Fixed Comp 2.4 Meg 5% 1/2W	Allen Bradley	RC20GF245J

8.4 Sweep & Modulator Module - Reference Designator Prefix 1A3 (cont'd)

REF. DESIG.	COMPONENT DESCRIPTION	MANUFACTURER	PART NO.
R62	Resistor, Fixed WW 100K 1% 1/2W	Pacific Resistor	50AP
R63	Resistor, Fixed WW 100K 1% 1/2W	Pacific Resistor	50AP
R64	Resistor, Fixed Comp 150K 5% 1/2W	Allen Bradley	RC20GF154J
R65	Resistor, Fixed Comp 150K 5% 1W	Allen Bradley	RC32GF154J
R66	Resistor, fixed Comp 470K 5% 1/2W	Allen Bradley	RC20GF474J
R67	Resistor, Fixed Comp 1 Meg 5% 1/2W	Allen Bradley	RC206F105J
R68	Resistor, Fixed Comp 150K 5% 1/2W	Allen Bradley	RC206F154J
R70	Resistor, Fixed Comp 180K 5% 1/2W	Allen Bradley	RC20GF184J
R71	Resistor, Fixed Comp 68K 5% 1/2W	Allen Bradley	RC20GF683J
R72	Resistor, Fixed Comp 100K 5% 2W	Allen Bradley	RC42GF104J
R73	Resistor, Fixed Comp 1.3 Meg 5% 1/2W	Allen Bradley	RC20GF135J
R74	Resistor, Fixed Comp 2.4 Meg 5% 1/2W	Allen Bradley	RC20GF245J
R75	Resistor, Fixed Comp 1.5 Meg 5% 1/2W	Allen Bradley	RC20GF155J
R76	Resistor, Var Comp 10K Pot 0.2W	CTS	CTS-70

8.4 Sweep & Modulator Module - Reference Designator Prefix 1A3 (cont'd)

REF. DESIG.	COMPONENT DESCRIPTION	MANUFACTURER	PART NO.
R77	Resistor, Fixed Comp 150K 5% 1/2W	Allen Bradley	RC20GF154J
R78	Resistor, Fixed Comp 150K 5% 1W	Allen Bradley	RC32GF154J
R79	Resistor, Fixed Comp 470K 5% 1/2W	Allen Bradley	RC20GF474J
R80	Resistor, Fixed Comp 1 Meg 5% 1/2W	Allen Bradley	RC20GF105J
R81	Resistor, Fixed Comp 150K 5% 1/2W	Allen Bradley	RC206F154J
R83	Resistor, Fixed Comp 180K 5% 1/2W	Allen Bradley	RC20GF184J
R84	Resistor, Fixed Comp 68K 5% 1/2W	Allen Bradley	RC20GF683J
R85	Resistor, Fixed Comp 75K 5% 2W	Allen Bradley	RC42GF753J
R86	Resistor, Fixed Comp 1.3 Meg 5% 1/2W	Allen Bradley	RC20GF135J
R87	Resistor, Fixed Comp 2.4 Meg 5% 1/2W	Allen Bradley	RC20GF245J
R88	Resistor, Fixed Comp 887K 1% 1/4W	IRC	Type MEB-T.O.
R89	Resistor, Fixed 887K 1% 1/4W	IRC	Type MEB-T.O.
R95	Resistor, Fixed Comp 430K 5% 1/2W	Allen Bradley	RC20GF434J
R96	Resistor, Fixed Comp 150K 5% 1W	Allen Bradley	RC32GF154J

8.4 Sweep & Modulator Module - Reference Designator Prefix 1A3 (cont'd)

REF. DESIG.	COMPONENT DESCRIPTION	MANUFACTURER	PART NO.
R97	Resistor Var. Comp 25K Pot 2W 10%	Allen Bradley	JLU-2531
R98	Resistor, Fixed Comp 15K 5% 1/2W	Allen Bradley	RC20GF153J
R99	Resistor, Fixed Comp 30K 5% 1/2W	Allen Bradley	RC20GF303J
R100	Resistor, Var. Comp 25K Pot 2W 10%	Allen Bradley	JLU-2531
R101	Resistor, Fixed Comp 110K 5% 1W	Allen Bradley	RC32GF114J
R102	Resistor, Fixed Comp 1.3 Meg 5% 1/2W	Allen Bradley	RC20GF135J
R103	Resistor, Fixed Comp 2.4 Meg 5% 1/2W	Allen Bradley	RC20GF245J
R104	Resistor, Fixed Comp 470K 5% 1/2W	Allen Bradley	RC20GF474J
R105	Resistor, Fixed Comp 2.2K 5% 1/2W	Allen Bradley	RC20GF222J
R106	Resistor, Fixed Comp 1 Meg 5% 1/2W	Allen Bradley	RC20GF105J
R107	Resistor, Fixed Comp 1K 5% 1/2W	Allen Bradley	RC20GF102J
R108	Resistor, Fixed Comp 1K 5% 1/2W	Allen Bradley	RC20GF102J
R109	Resistor, Fixed Comp 1K 5% 1/2W	Allen Bradley	RC20GF102J
R110	Resistor, Fixed Comp 1K 5% 1/2W	Allen Bradley	RC20GF102J

8.4 Sweep & Modulator Module - Reference Designator Prefix 1A3 (cont'd)

REF. DESIG.	COMPONENT DESCRIPTION	MANUFACTURER	PART NO.
R111	Resistor, Fixed Comp 100K 5% 2W	Allen Bradley	RC42GF104J
R112	Resistor, Var. Comp 250K Pot 2W, 10%	Allen Bradley	JLU-2541
R113	Resistor, Fixed WW 10K 5% 5W	Sprague	243E1035
R114	Resistor, Fixed WW 12K 5% 5W	Sprague	243E1235
R115	Resistor, Fixed Comp 51K 5% 2W	Allen Bradley	RC42GF513J
R120	Resistor, Fixed Comp 240K 5% 1W	Allen Bradley	RC32GF244J
TP1	Jack, Tip Green	H. H. Smith	1501-104
TP2	Jack, Tip Green	H. H. Smith	1501-104
TP3	Jack, Tip Green	H. H. Smith	1501-104
V1	Tube		12AX7
V2	Tube		6AN8A
V3	Tube		12AX7
V4	Tube		6AN8A
V5	Tube		12AX7
V6	Tube		6AN8A
V7	Tube		12AX7
V8	Tube		6AN8A
V9	Tube		12AX7

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8.4 Sweep & Modulator Module - Reference Designator Prefix 1A3 (cont'd)

REF. DESIG.	COMPONENT DESCRIPTION	MANUFACTURER	PART NO.
V10	Tube		6AN8A
V11	Tube		12AX7
V12	Tube		6AN8A

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8.5 Power Supply Module - Reference Designator Prefix 1A4

REF. DESIG.	COMPONENT DESCRIPTION	MANUFACTURER	PART NO.
* CR1 thru CR20	Diode, Semiconductor Device	Texas Inst.	1N2071
C1	Capacitor, Electrolytic, 20MFD, 500V	Sprague	TVA-1906
C2	Capacitor, Disc. 0.001 MFD, 1KV	Elmenco	CCD102
C3	Capacitor, Mylar, 0.05 MFD, 400V	ELPAC	MD1178
C4	Capacitor, Electrolytic, 40MFD, 450V	Sprague	TVA-1712
C6	Capacitor, Mica, 150 MMFD, ±5%, 500V	Elmenco	CM15E151
C7	Capacitor, Disc. 0.01 MFD, 300V	Elmenco	CCD103
C8	Capacitor, Mylar, 0.05 MFD, 400V	ELPAC	MD1178
C9	Capacitor, Electrolytic, 40MFD, 450V	Sprague	TVA-1712
C10	Capacitor, Mylar, 0.2 MFD, 300V	ELPAC	MD1733
C12	Capacitor, Electrolytic, 4MFD, 450V	Sprague	TVA-1702
C13	Capacitor, Electrolytic, 20MFD, 500V	Sprague	TVA-1712
C14	Capacitor, Mica, 100MMFD	Elmenco	CM15E101
C15	Capacitor, Mylar, .33MFD 600V	Mallory	PVC6033

8.5 Power Supply Module - Reference Designator Prefix 1A4 (cont'd)

REF. DESIG.	COMPONENT DESCRIPTION	MANUFACTURER	PART NO.
C16	Capacitor, Sil-Mica (Fact. Select)		CM15E
DS1	Lamp, Glow (Neon)	G. E.	NE-2
DS2	Lamp, Glow (Neon)	G. E.	NE-2
P1	Connector, Blue Ribbon	Amphenol	26-4100-24P
R1	Resistor, Wirewound 5 ohms, ±5%, 5W	Sprague	243E5R05
R2	Resistor, Composition, 510K, ±5%, 1/2W	Allen Bradley	EB
R3	Resistor, Composition, 1K, ±5%, 1/2W	Allen Bradley	EB
R4	Resistor, Composition, 1K, ±5%, 1/2W	Allen Bradley	EB
R5	Resistor, Composition, 390K, ±5%, 1/2W	Allen Bradley	EB
R6	Resistor, Composition, 510K, ±5%, 1/2W	Allen Bradley	EB
R7	Resistor, Composition, 510K, ±5%, 1/2W	Allen Bradley	EB
R8	Resistor, Composition, 360K, ±5%, 1/2W	Allen Bradley	EB
R9	Resistor, Wirewound, 400K, ±1%, 1/2W	Pacific Resistor	50 AP
R10	Resistor, Wirewound, 400K, ±1%, 1/2W	Pacific Resistor	50 AP

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8.5 Power Supply Module - Reference Designator Prefix 1A4 (cont'd)

REF. DESIG.	COMPONENT DESCRIPTION	MANUFACTURER	PART NO.
R11	Resistor, Composition, 10 ohms, ± 5%, 2W	Allen Bradley	HB
R12	Resistor, Composition, 1K ±5%, 1/2W	Allen Bradley	EB
R13	Resistor, Composition, 240K, ±5%, 1/2W	Allen Bradley	EB
R14	Resistor, Composition, 91K, ±5%, 2W	Allen Bradley	HB
R16	Resistor, Composition, 390K, ±5%, 1W	Allen Bradley	GB
R17	Resistor, Composition, 390K, ±5%, 1W	Allen Bradley	GB
R18	Resistor, Composition, 120K, ±5%, 1/2W	Allen Bradley	EB
R19	Resistor, Wirewound, 400K, ±1%, 1/2W	Pacific Resistor	50AP
R20	Resistor, Wirewound, 160K, ±1%, 1/2W	Pacific Resistor	50AP
R21	Resistor, Composition, 100K, ±5%, 1/2W	Allen Bradley	EB
R22	Resistor, Composition, 6.8K, ±5%, 1/2W	Allen Bradley	EB
R23	Resistor, Composition, 1 Meg., ±5%, 1/2W	Allen Bradley	EB
R24	Resistor, Composition, 56K, ±5%, 1/2W	Allen Bradley	EB
R25	Resistor, Composition, 47K, ±5%, 1/2W	Allen Bradley	EB

8.5 Power Supply Module - Reference Designator Prefix 1A4 (cont'd)

REF. DESIG.	COMPONENT DESCRIPTION	MANUFACTURER	PART NO.
R26	Resistor, Composition, 240 ohms, ±5%, 1/2W	Allen Bradley	EB
R27	Resistor, Composition, 470K, ±5%, 1/2W	Allen Bradley	EB
R28	Resistor, Composition, 1K, ±5%, 1/2W	Allen Bradley	EB
R29	Resistor, Composition, 100K, ±5%, 1/2W	Allen Bradley	EB
R30	Resistor, Composition, 1 Meg., ±5%, 1/2W	Allen Bradley	EB
R31	Resistor, Composition, 100 ohms, ±5%, 1/2W	Allen Bradley	EB
R32	Resistor, Variable, 15K, 5W, Wirewound	Centralab	WN153
R34	Resistor, Wirewound, 3.3K, 5%, 10W	Sprague	247E3325
T1	Transformer, Modulation Amplifier	Remanco	10043
V1	Tube, Electron		6AS7GA
V2	Tube, Electron		12AX7
V3	Tube, Electron		12AX7
V4	Tube, Electron		6AS7GA
V5	Tube, Electron		12AX7
V6	Tube, Electron		5651
V7	Tube, Electron		12AX7
V8	Tube, Electron		6U8A

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8.6 Special Function Module SF-1 - Reference Designator Prefix 1A5

REF. DESIG.	COMPONENT DESCRIPTION	MANUFACTURER	PART NO.
C1	Capacitor, Disc., .005MF, 1000V	Elmenco	CCD-502
C2	Capacitor, Disc., 15PF, 1000V	Elmenco	CCD-150
C3	Capacitor, Disc., .005MF, 1000V	Elmenco	CCD-502
C4	Capacitor, Disc., 15PF, 1000V	Elmenco	CCD-150
C5	Capacitor, Disc., .003MF, 1000V	Elmenco	CCD-302
C6	Capacitor, Mylar .2MF, 300V	ELPAC	MD-1733 262
C7	Capacitor, Electrolytic 4MF, 450V	Sprague	TVA-1702
C8	Capacitor, Mylar .33MF, 600V	Mallory	PVC6033
C9	Capacitor, Disc. .003MF, 1000V	Elmenco	CCD-302
C10	Capacitor, Disc. .003MF, 1000V	Elmenco	CCD-302
C11	Capacitor, Disc. .003MF, 1000V	Elmenco	CCD-302
C12	Capacitor, Disc. .005MF, 1000V	Elmenco	CCD-502
C13	Capacitor, Disc. 15MF, 1000V	Elmenco	CCD-150
C14	Capacitor, Disc. .003MF, 1000V	Elmenco	CCD-302

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8.6 Special Function Module SF-1 - Reference Designator Prefix 1A5 (cont'd)

REF. DESIG.	COMPONENT DESCRIPTION	MANUFACTURER	PART NO.
C15	Capacitor, Disc. .005MF, 1000V	Elmenco	CCD-502
C16	Capacitor, Disc. .003MF, 1000V	Elmenco	CCD-302
C17	Capacitor, Disc. 15PF, 1000V	Elmenco	CCD-150
C18	Capacitor, Disc. .003MF, 1000V	Elmenco	CCD-302
C19	Capacitor, Disc. .005MF, 1000V	Elmenco	CCD-502
C20	Capacitor, Disc. .003MF, 1000V	Elmenco	CCD-302
C21	Capacitor, Disc. 15PF, 1000V	Elmenco	CCD-150
C22	Capacitor, Mica 15PF, 1000V	Elmenco	CCD-150
C23	Capacitor, Mica 20PF, 500V	Elmenco	C200J
C24	Capacitor, Mica 100PF, 500V	Elmenco	E101J
C26	Capacitor, Disc. 15PF, 1000V	Elmenco	CCD-150
C27	Capacitor, Disc. 15PF, 1000V	Elmenco	CCD-150
C28	Capacitor, Mica (Factory Select)	Elmenco	CM15E
C29	Capacitor, Mica 100PF, 500V	Elmenco	E101J

8.6 Special Function Module SF-1 - Reference Designator Prefix 1A5 (cont'd)

REF. DESIG.	COMPONENT DESCRIPTION	MANUFACTURER	PART NO.
CR1, CR2	Diode, General Purpose Silicon	PSI	1N485
P1	Connector, Chassis Mount	Amphenol	26-4100-24P
R1	Resistor, Metallic Film 100K, 1%, 1/8W	IRC	MEA-TO-100K-1%
R2	Resistor, Metallic Film, 100K, 1%, 1/8W	IRC	MEA-TO-100K-1%
R3	Resistor, Fixed Comp 150K, 5%, 1W	Allen Bradley	GB
R4	Resistor, Fixed Comp 150K, 5%, 1/2W	Allen Bradley	EB
R5	Resistor, Fixed Comp 1 Meg., 5%, 1/2W	Allen Bradley	EB
R6	Resistor, Variable 10K, 10%, 1W	Atohm	W10 1L (PM1)
R7	Resistor, Fixed Comp. 470K, 5%, 1/2W	Allen Bradley	EB
R8	Resistor, Fixed Comp. 1K, 5%, 1/2W	Allen Bradley	EB
R9	Resistor, Fixed Comp. 1M, 5%, 1/2W	Allen Bradley	EB
R10	Resistor, Fixed Comp. 68K, 5%, 1/2W	Allen Bradley	EB
R11	Resistor, Fixed Comp. 180K, 5%, 1/2W	Allen Bradley	EB
R12	Resistor, Fixed Comp 150K, 5%, 1/2W	Allen Bradley	EB

8.6 Special Function Module SF-1 - Reference Designator Prefix 1A5 (cont'd)

REF. DESIG.	COMPONENT DESCRIPTION	MANUFACTURER	PART NO.
R13	Resistor, Fixed Comp. 100K, 5%, 2W	Allen Bradley	HB
R14	Resistor, Fixed Comp. 1.3 Meg., 5%, 1/2W	Allen Bradley	EB
R15	Resistor, Fixed Comp. 2.4 Meg., 5%, 1/2W	Allen Bradley	EB
R16	Resistor, Fixed Comp. 430 ohms, 5%, 1/2W	Allen Bradley	EB
R17	Resistor, Fixed Comp. 100K, 5%, 2W	Allen Bradley	HB
R18	Resistor, Fixed Comp. 430 ohms, 5%, 1/2W	Allen Bradley	EB
R19	Resistor, Fixed Comp. 100K, 5%, 2W	Allen Bradley	HB
R20	Resistor, Fixed Comp. 130K, 5%, 1/2W	Allen Bradley	EB
R22	Resistor, Fixed Comp. 150K, 5%, 1W	Allen Bradley	GB
R23	Resistor, Fixed Comp. 150K, 5%, 1/2W	Allen Bradley	EB
R24	Resistor, Fixed Comp. 1 Meg., 5%, 1/2W	Allen Bradley	EB
R25	Resistor, Variable 10K, 10%, 1W	Atohm	W10 1L (PM1)
R26	Resistor, Fixed Comp. 470K, 5%, 1/2W	Allen Bradley	EB
R27	Resistor, Fixed Comp. 1K, 5%, 1/2W	Allen Bradley	EB

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8.6 Special Function Module SF-1 - Reference Designator Prefix 1A5 (cont'd)

REF. DESIG.	COMPONENT DESCRIPTION	MANUFACTURER	PART NO.
R28	Resistor, Fixed Comp. 1 Meg., 5%, 1/2W	Allen Bradley	EB
R29	Resistor, Fixed Comp. 68K, 5%, 1/2W	Allen Bradley	EB
R30	Resistor, Fixed Comp. 180K, 5%, 1/2W	Allen Bradley	EB
R31	Resistor, Fixed Comp. 150K, 5%, 1/2W	Allen Bradley	EB
R32	Resistor, Wirewound 12K, 5%, 5W	Sprague	243E1235
R33	Resistor, Fixed Comp. 1.3 Meg., 5%, 1/2W	Allen Bradley	EB
R34	Resistor, Fixed Comp. 100K, 5%, 2W	Allen Bradley	HB
R35	Resistor, Fixed Comp. 2.4 Meg., 5%, 1/2W	Allen Bradley	EB
R36	Resistor, Fixed Comp. 100K, 5%, 1/2W	Allen Bradley	EB
R37	Resistor, Fixed Comp. 47K, 5%, 1/2W	Allen Bradley	EB
R38	Resistor, Fixed Comp. 1 Meg., 5%, 1/2W	Allen Bradley	EB
R39	Resistor, Fixed Comp. 6.8K, 5%, 1/2W	Allen Bradley	EB
R40	Resistor, Fixed Comp. 240 ohms, 5%, 1/2W	Allen Bradley	EB
R41	Resistor, Fixed Comp. 56K, 5%, 1/2W	Allen Bradley	EB

8.6 Special Function Module SF-1 - Reference Designator Prefix 1A5 (cont'd)

REF. DESIG.	COMPONENT DESCRIPTION	MANUFACTURER	PART NO.
R42	Resistor, Fixed Comp. 330K, 5%, 1/2W	Allen Bradley	EB
R43	Resistor, Variable 250K, 10%, 2W	Ohmite	CLU2541
R44	Resistor, Fixed Comp. 150K, 5%, 1W	Allen Bradley	GB
R45	Resistor, Fixed Comp. 150K, 5%, 1/2W	Allen Bradley	EB
R46	Resistor, Fixed Comp. 1 Meg., 5%, 1/2W	Allen Bradley	EB
R47	Resistor, Fixed Comp. 470K, 5%, 1/2W	Allen Bradley	EB
R48	Resistor, Variable 10K, 10%, 1W	Atohm	W10 1L (PM1)
R49	Resistor, Fixed Comp. 1K, 5%, 1/2W	Allen Bradley	EB
R50	Resistor, Fixed Comp. 68K, 5%, 1/2W	Allen Bradley	EB
R51	Resistor, Fixed Comp. 1 Meg., 5%, 1/2W	Allen Bradley	EB
R52	Resistor, Carbon Film 4.22 Meg., 1%, 1/2W	IRC	MDC-4.22M-1%
R53	Resistor, Wirewound 25K, 1%, 3W	Dalohm	RS-2B
R54	Resistor, Wirewound 12.0K, 1%, 2W	Dalohm	RS-2A
R55	Resistor, Wirewound 12.5K, 1%, 2W	Dalohm	RS-2A

8.6 Special Function Module SF-1 - Reference Designator Prefix 1A5 (cont'd)

REF. DESIG.	COMPONENT DESCRIPTION	MANUFACTURER	PART NO.
R56	Resistor, Wirewound 25K, 1%, 3W	Dalohm	RS-2B
R57	Resistor, Fixed Comp. 180K, 5%, 1/2W	Allen Bradley	EB
R58	Resistor, Fixed Comp. 150K, 5%, 1/2W	Allen Bradley	EB
R59	Resistor, Fixed Comp. 1.3 Meg., 5%, 1/2W	Allen Bradley	EB
R60	Resistor, Fixed Comp. 100K, 5%, 2W	Allen Bradley	HB
R61	Resistor, Fixed Comp. 2.4 Meg., 5%, 1/2W	Allen Bradley	EB
R62	Resistor, Fixed Comp. 100K, 5%, 1/2W	Allen Bradley	EB
R63	Resistor, Fixed Comp. 240K, 5%, 1/2W	Allen Bradley	EB
R64	Resistor, Variable 250K, 10%, 2W	Ohmite	CLU 2541
R65	Resistor, Fixed Comp. 560K, 5%, 1/2W	Allen Bradley	EB
R66	Resistor, Fixed Comp. 150K, 5%, 1W	Allen Bradley	GB
R67	Resistor, Fixed Comp. 150K, 5%, 1/2W	Allen Bradley	EB
R68	Resistor, Fixed Comp. 1 Meg., 5%, 1/2W	Allen Bradley	EB
R69	Resistor, Variable 10K, 10%, 1W	Atohm	W10 1L (PM1)

8.6 Special Function Module SF-1 - Reference Designator Prefix 1A5 (cont'd)

REF. DESIG.	COMPONENT DESCRIPTION	MANUFACTURER	PART NO.
R70	Resistor, Fixed Comp. 470K, 5%, 1/2W	Allen Bradley	EB
R71	Resistor, Fixed Comp. 1K, 5%, 1/2W	Allen Bradley	EB
R72	Resistor, Fixed Comp. 1 Meg., 5%, 1/2W	Allen Bradley	EB
R73	Resistor, Fixed Comp. 68K, 5%, 1/2W	Allen Bradley	EB
R74	Resistor, Fixed Comp. 180K, 5%, 1/2W	Allen Bradley	EB
R75	Resistor, Fixed Comp. 150K, 5%, 1/2W	Allen Bradley	EB
R76	Resistor, Fixed W.W. 12K, 5%, 5W	Sprague	243E 1235
R77	Resistor, Fixed Comp. 1.3 Meg., 5%, 1/2W	Allen Bradley	EB
R78	Resistor, Fixed Comp. 100K, 5%, 2W	Allen Bradley	HB
R79	Resistor, Fixed Comp. 2.4 Meg., 5%, 1/2W	Allen Bradley	EB
R80	Resistor, Fixed Comp. 150K, 5%, 1W	Allen Bradley	GB
R81	Resistor, Variable 25K, 10%, 2W	Ohmite	CLU 2531
R82	Resistor, Fixed Comp. 15K, 5%, 1/2W	Allen Bradley	EB
R83	Resistor, Fixed Comp. 110K, 5%, 1W	Allen Bradley	GB

8.6 Special Function Module SF-1 - Reference Designator Prefix 1A5 (cont'd)

REF. DESIG.	COMPONENT DESCRIPTION	MANUFACTURER	PART NO.
R84	Resistor, Variable 25K, 10%, 2W	Ohmite	CLU 2531
R85	Resistor, Fixed Comp. 30K, 5%, 1/2W	Allen Bradley	EB
R86	Resistor, Metallic Film, 1 Meg., 1%, 1/4W	IRC	MEB-T-O-1M-1%
R87	Resistor, Metallic Film, 1 Meg., 1%, 1/4W	IRC	MEB-T-O-1M-1%
R88	Resistor, Fixed Comp. 150K, 5%, 1W	Allen Bradley	GB
R89	Resistor, Fixed Comp. 150K, 5%, 1/2W	Allen Bradley	EB
R90	Resistor, Fixed Comp. 1 Meg., 5%, 1/2W	Allen Bradley	EB
R91	Resistor, Variable 10K, 10%, 1W	Atohm	W10 1L (PM1)
R92	Resistor, Fixed Comp. 470K, 5%, 1/2W	Allen Bradley	EB
R93	Resistor, Fixed Comp. 1K, 5%, 1/2W	Allen Bradley	EB
R94	Resistor, Fixed Comp. 1 Meg., 5%, 1/2W	Allen Bradley	EB
R95	Resistor, Fixed Comp. 68K, 5%, 1/2W	Allen Bradley	EB
R96	Resistor, Fixed Comp. 180K, 5%, 1/2W	Allen Bradley	EB
R97	Resistor, Fixed Comp. 150K, 5%, 1/2W	Allen Bradley	EB

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8.6 Special Function Module SF-1 - Reference Designator Prefix 1A5 (cont'd)

REF. DESIG.	COMPONENT DESCRIPTION	MANUFACTURER	PART NO.
R98	Resistor, Wirewound 12K, 5%, 5W	Sprague	243E 1235
R99	Resistor, Fixed Comp. 1.3 Meg., 5%, 1/2W	Allen Bradley	EB
R100	Resistor, Fixed Comp. 100K, 5%, 2W	Allen Bradley	HB
R101	Resistor, Fixed Comp. 2.4 Meg., 5%, 1/2W	Allen Bradley	EB
R103	Resistor, Variable 2.5K, 10%, 1W	Atohm	W10 1L (PM1)
R104	Resistor, Fixed Comp. 100K, 5%, 2W	Allen Bradley	HB
R105	Resistor, Wirewound 2.2K, 5%, 25W	Dalohm	RH-25
T1	Transformer Output Transformer	Remanco	10043
TP1,2 & 3	Test Points (3 Req'd.) Pin Jack	H. H. Smith	Type 1501
V1	Tube		12AX7
V2	Tube		6AN8A
V3	Tube		12AX7
V4	Tube		6AN8A
V5	Tube		6U8A
V6	Tube		12AX7
V7	Tube		6AN8A

8.6 Special Function Module SF-1 - Reference Designator Prefix 1A5 (cont'd)

REF. DESIG.	COMPONENT DESCRIPTION	MANUFACTURER	PART NO.
V8	Tube		12AX7
V9	Tube		6AN8A
V10	Tube		12AX7
V11	Tube		6AN8A
Z1	Modulator Plug In	Remanco	500419
Z2	Triangle Matrix Plug In	Remanco	501527

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8.7 Extended Frequency Module EF-1 - Reference Designator Prefix 1A6

REF. DESIG.	COMPONENT DESCRIPTION	MANUFACTURER	PART NO.
*C1	Capacitor, 31.7MFD, ±1%, 200WVDC	Remanco	10010
*C2	Capacitor, 31.7MFD, ±1%, 200WVDC	Remanco	10010
*C3	Capacitor, 31.7MFD, ±1%, 200WVDC	Remanco	10010
*C4	Capacitor, 31.7MFD, ±1%, 200WVDC	Remanco	10010
P1	Connector, Blue Ribbon	Amphenol	26-4100-24P

*C1, C2, C3, C4 each consist of capacitors selected to total 31.7MFD.

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8.8 Front Panel - Reference Designator Prefix 1A7
Models 902D, 902DSG

REF. DESIG.	COMPONENT DESCRIPTION	MANUFACTURER	PART NO.
A1	Assy-Carrier Plugin (60/400 cps)	Remanco	500437
C1	Capacitor, Electrolytic 30MF, 50 V	Cornell-Dubilier	NLW 30-50
C2A	Capacitor, Mylar 10MF, 2%, 200 V	Remanco	C100522
C2B	Capacitor, Mylar 10MF, 2%, 200 V	Remanco	C100522
C3A	Capacitor, Mylar 0.1MF, 2%, 200 V	Remanco	C100322
C3B	Capacitor, Mylar 0.1MF, 2%, 200V	Remanco	C100322
C4	Capacitor, Mylar .02MF, 2%, 300V	Remanco	C200232
C5	Capacitor, Mylar 3.17MF, 1%, 200 V	Remanco	C317421
C6	Capacitor, Mylar 0.316, 1%, 200V	Remanco	C316321
C7	Capacitor, Mylar .0316MF, 1%, 200V	Remanco	C316221
C8	Capacitor, Mylar 3.17MF, 1%, 200 V	Remanco	C317421
C9	Capacitor, Mylar 0.316MF, 1%, 200V	Remanco	C316321
C10	Capacitor, Mylar .0316MF, 1%, 200 V	Remanco	C316221
C11	Capacitor, Mylar 3.17MF, 1%, 200V	Remanco	C317421

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8.8 Front Panel - Reference Designator Prefix 1A7 (cont'd)
Models 902D, 902DSG

REF. DESIG.	COMPONENT DESCRIPTION	MANUFACTURER	PART NO.
C12	Capacitor, Mylar 0.316MF, 1%, 200V	Remanco	C316321
C13	Capacitor, Mylar .0316MF, 1%, 200V	Remanco	C316221
C14	Capacitor, Mylar 3.17MF, 1%, 200V	Remanco	C317421
C15	Capacitor, Mylar 0.316MF, 1%, 200V	Remanco	C316321
C16	Capacitor, Mylar .0316MF, 1%, 200V	Remanco	C316221
C17	Capacitor, Sil Mica 100PF, 500V	Elmenco	CM-15E-101
C18A	Capacitor, Mylar 1.0MF, 200V, 2%	Remanco	C100422
C18B	Capacitor, Mylar 1.0MF, 200V, 2%	Remanco	C100422
DS1	Assembly, Lamp, Neon 68K, 115V	Eldema	1EG3-6055
DS2	Assembly, Lamp, Neon 68K, 115V	Eldema	1EG3-6055
DS3	Tube, Indicator Nixie	Burroughs	B5092
DS4	Tube, Indicator Nixie	Burroughs	B5092
DS5	Tube, Indicator Nixie	Burroughs	B5092
DS6	Bulb, 6.3V,	G.E.	#47

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8.8 Front Panel - Reference Designator Prefix 1A7 (cont'd)
Models 902D, 902DSG

REF. DESIG.	COMPONENT DESCRIPTION	MANUFACTURER	PART NO.
DS7	Bulb, 6.3V	G.E.	#47
DS8	Bulb, 6.3V	G.E.	#47
DS9	Bulb, 6.3V	G.E.	#47
F1	Fuse, (115V) 4 Amp 3AG Slo Blo	Littelfuse	313004
F1	Fuse, (230V) 2 Amp 3AG, Slo Blo	Littelfuse	313002
F2	Fuse, (115V) 3 Amp 3AG, Slo Blo	Littelfuse	313003
F2	Fuse (230V), 1.5 Amp 3AG, Slo Blo	Littelfuse	31301.5
J2	Socket, 9 Pin	Elco	TS103PO3
J3	Terminal Post Red, 5 Way	Superior	DF30RC
J4A	Terminal Post Red, 5 Way	Superior	DF30RC
J4B	Terminal Post Black, 5 Way	Superior	DF30BC
J5A	Terminal Post Red, 5 Way	Superior	DF30RC
J5B	Terminal Post Red, 5 Way	Superior	DF30RC
J6A	Terminal Post Red, 5 Way	Superior	DF30RC

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8.8 Front Panel - Reference Designator Prefix 1A7 (cont'd)
Models 902D, 902DSG

REF. DESIG.	COMPONENT DESCRIPTION	MANUFACTURER	PART NO.
J6B	Terminal Post Black, 5 Way	Superior	DF30BC
J7A	Terminal Post Red, 5 Way	Superior	DF30RC
J7B	Terminal Post Black, 5 Way	Superior	DF30BC
J8A	Terminal Post Red, 5 Way	Superior	DF30RC
J8B	Terminal Post Black, 5 Way	Superior	DF30BC
K1	Relay - 4 PDT, 110VDC, 11K Coil	Potter Brumfield	KHP17D11
P1A	Connector Blue Ribbon	Amphenol	26-159-32
P1B	Connector Blue Ribbon	Amphenol	26-4100-32P
P1C	Connector Blue Ribbon	Amphenol	26-4100-24P
R2	Resistor, Dep. Carbon 24K, 1%, 1/2W	IRC	RN20X
R3	Resistor, Dep. Carbon 24K, 1%, 1/2W	IRC	RN20X
R5	Resistor, Variable 5K, 4 Gang	Remanco	10012
R7	Resistor, Variable 2x20K Sine, 20K, Lin.	Remanco	10036
R8	Resistor, Variable 10K, 2W, 10%	Allen Bradley	JLU

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8.8 Front Panel - Reference Designator Prefix 1A7 (cont'd)
Models 902D, 902DSG

REF. DESIG.	COMPONENT DESCRIPTION	MANUFACTURER	PART NO.
R9	Resistor, Variable 10K, & 10K, 3%, 3T	Remanco	10050
R12	Resistor, Fixed Comp. 22 ohm, 5%, 1W	Allen Bradley	GB
R13	Resistor, Fixed Comp 1.5K, 5%, 1/2W	Allen Bradley	EB
R14	Resistor, Fixed Comp. 18K, 5%, 2W.	Allen Bradley	HB
R58	Resistor, Fixed Wirewound 30K, 5%, 5W	Sprague	243E3035
R59	Resistor, Variable 500 ohm, 2W, 10%	Allen Bradley	JLU
R60	Resistor, Fixed Comp 1K, 5%, 1/2W	Allen Bradley	EB
R64	Resistor, Fixed Comp 82K, 5%, 1W	Allen Bradley	GB
R65	Resistor, Fixed Comp 82K, 5%, 1W	Allen Bradley	GB
R66	Resistor, Fixed Comp 82K, 5%, 1W	Allen Bradley	GB
R67	Resistor, Fixed Comp 10 ohm, 5%, 1/2W	Allen Bradley	EB
R76	Resistor, Variable 5K, 2W, 10%	Allen Bradley	JLU
R77	Resistor, Fixed Wirewound, 60K, 1%, 5W	Dale	RS-5
R80	Resistor, Fixed Comp 1.15K, 1%, 1/4W	IRC	MEB-TO

8.8 Front Panel - Reference Designator Prefix 1A7 (cont'd)
Models 902D, 902DSG

REF. DESIG.	COMPONENT DESCRIPTION	MANUFACTURER	PART NO.
R81	Resistor, Fixed Comp Selected,5%, 1/2W	Allen Bradley	EB
R82	Resistor, Met. Film 10K, 1%, 1/4W	IRC	MEB-TO
R83	Resistor, Met. Film 140K, 1%, 1W	IRC	MEF-TO
R84	Resistor, Variable 3.5K, 2W, 10%	Allen Bradley	JLU
R85	Resistor, Fixed Wire-wound, 17.5K, 1%, 5W	Dale	RS-5
R86	Resistor, Fixed Comp 820 ohm, 5%, 1W	Allen Bradley	GB
R87	Resistor, Fixed Comp 330K, 5%, 1/2W	Allen Bradley	EB
R88	Resistor, Variable 25K, 2W, 10%	Allen Bradley	JLU
R89	Resistor, Variable 1K, 2W, 10%	Allen Bradley	JLU
R90	Resistor, Variable 5M, 2W, 20%	Allen Bradley	JLU
R91	Resistor, Metallic Film 20.0K, 1%, 1/8W	IRC	MEA-TO
R92	Resistor, Metallic Film 20.5K, 1%, 1/8W	IRC	MEA-TO
R93	Resistor, Metallic Film 21.0K, 1%, 1/8W	IRC	MEA-TO

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8.8 Front Panel - Reference Designator Prefix 1A7 (cont'd)
Models 902D, 902DSG

REF. DESIG.	COMPONENT DESCRIPTION	MANUFACTURER	PART NO.
R94	Resistor, Metallic Film 21.0K, 1%, 1/8W	IRC	MEA-TO
R95	Resistor, Variable 1K, 2W, 10%	Allen Bradley	JLU
R96	Resistor, Metallic Film 210K, 1%, 1/2W	IRC	MEC-TO
R97	Resistor, Metallic Film 9.31K, 1%, 1/4W	IRC	MEB-TO
R98	Resistor, Fixed Comp 18K, 5%, 1W	Allen Bradley	GB
R102	Resistor, Fixed Comp 10K, 5%, 1/2W	Allen Bradley	EB
R103	Resistor, Fixed Comp 330 ohm, 5%, 1/2W	Allen Bradley	EB
S1	Switch, Toggle DPDT		ST22N
S2	Switch, Toggle DPDT		ST22N
S3	Switch, Rotary 9P, 2-5 Position	Centralab	PA2029
S4	Switch, Rotary 6P, 2-5 Position	Centralab	PA2021
S5	Switch, Toggle DPDT		ST22N
S6	Switch, Toggle DPDT		ST22N

8.8 Front Panel - Reference Designator Prefix 1A7 (cont'd)
Models 902D, 902DSG

REF. DESIG.	COMPONENT DESCRIPTION	MANUFACTURER	PART NO.
S7	Switch, Rotary 6P, 2-5 position	Centralab	PA2021
S8	Switch, Push Button SPDT Moment	Switchcraft	903
S9, S10	Switch, Rotary (Frequency switches assy. with resistors)	Remanco	502456
S11	Switch, Rotary 6P, 2-5 Position	Centralab	PA2021
XDS3	Socket, Nixie	Burroughs	HSK-112
XDS4	Socket, Nixie	Burroughs	HSK-112
XDS5	Socket, Nixie	Burroughs	HSK-112
XF1	Holder, Fuse 5A, 250V	Bussman	HKP
XF2	Holder, Fuse 5A, 250V	Bussman	HKP
XK1	Socket, Relay	Potter-Brumfield	9HK1

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8.8.1 Front Panel - Reference Designator Prefix 1A7
Model 902DK

REF. DESIG.	COMPONENT DESCRIPTION	MANUFACTURER	PART NO.
A1	Assy-Carrier Plugin (60/400 cps)	Remanco	500437
C1	Capacitor, Electrolytic 30MF, 50V	Cornell-Dubilier	NLW 30-50
C2A	Capacitor, Mylar 10MF, 2%, 200V	Remanco	C100522
C2B	Capacitor, Mylar 10MF, 2%, 200V	Remanco	C100522
C3A	Capacitor, Mylar 0.1MF, 2%, 200V	Remanco	C100322
C3B	Capacitor, Mylar 0.1MF, 2%, 200V	Remanco	C100322
C4	Capacitor, Mylar .02MF, 2%, 300V	Remanco	C200232
C5	Capacitor, Mylar 3.17MF, 1%, 200V	Remanco	C317421
C6	Capacitor, Mylar 0.316, 1%, 200V	Remanco	C316321
C7	Capacitor, Mylar .0316MF, 1%, 200V	Remanco	C316221
C8	Capacitor, Mylar 3.17MF, 1%, 200V	Remanco	C317421
C9	Capacitor, Mylar 0.316MF, 1%, 200V	Remanco	C316321
C10	Capacitor, Mylar .0316MF, 1%, 200V	Remanco	C316221
C11	Capacitor, Mylar 3.17MF, 1%, 200V	Remanco	C317421

ASSEM. 502445

8.8.1 Front Panel - Reference Designator Prefix 1A7 (cont'd)
Model 902DK

REF. DESIG.	COMPONENT DESCRIPTION	MANUFACTURER	PART NO.
C12	Capacitor, Mylar 0.316MF, 1%, 200V	Remanco	C316321
C13	Capacitor, Mylar .0316MF, 1%, 200V	Remanco	C316221
C14	Capacitor, Mylar 3.17MF, 1%, 200V	Remanco	C317421
C15	Capacitor, Mylar 0.316MF, 1%, 200V	Remanco	C316321
C16	Capacitor, Mylar .0316MF, 1%, 200V	Remanco	C316221
C17	Capacitor, Sil Mica 100PF, 500V	Elmenco	CM-15E-101
C18A	Capacitor, Mylar 1.0MF, 200V, 2%	Remanco	C100422
C18B	Capacitor, Mylar 1.0MF, 200V, 2%	Remanco	C100422
DS1	Assembly, Lamp, Neon 68K, 115V	Eldema	1EG3-6055
DS2	Assembly, Lamp, Neon 68K, 115V	Eldema	1EG3-6055
DS3	Tube, Indicator Nixie	Burroughs	B5092
DS4	Tube, Indicator Nixie	Burroughs	B5092
DS5	Tube, Indicator Nixie	Burroughs	B5092
DS6	Bulb, 6.3V	G.E.	#47

ASSEM. 502445

8.8.1 Front Panel - Reference Designator Prefix 1A7 (cont'd)
Model 902DK

REF. DESIG.	COMPONENT DESCRIPTION	MANUFACTURER	PART NO.
DS7	Bulb, 6.3V	G.E.	#47
DS8	Bulb, 6.3V	G.E.	#47
DS9	Bulb, 6.3V	G.E.	#47
F1	Fuse,(115V) 4 Amp 3AG Slo Blo	Littelfuse	313004
F1	Fuse, (230V) 2 Amp 3AG, Slo Blo	Littelfuse	313002
F2	Fuse, (115V) 3 Amp 3AG, Slo Blo	Littelfuse	313003
F2	Fuse (230V), 1.5 Amp 3AG, Slo Blo	Littelfuse	31301.5
J2	Socket, 9 Pin	Elco	TS103PO3
J3	Terminal Post Red, 5 Way	Superior	DF30RC
J4A	Terminal Post Red, 5 Way	Superior	DF30RC
J4B	Terminal Post Black, 5 Way	Superior	DF30BC
J5A	Terminal Post Red, 5 Way	Superior	DF30RC
J5B	Terminal Post Red, 5 Way	Superior	DF30RC
J6A	Terminal Post Red, 5 Way	Superior	DF30RC

ASSEM. 502445

8.8.1 Front Panel - Reference Designator Prefix 1A7 (cont'd)
Model 902DK

REF. DESIG.	COMPONENT DESCRIPTION	MANUFACTURER	PART NO.
J6B	Terminal Post Black, 5 Way	Superior	DF30BC
J7A	Terminal Post Red, 5 Way	Superior	DF30RC
J7B	Terminal Post Black, 5 Way	Superior	DF30BC
J8A	Terminal Post Red, 5 Way	Superior	DF30RC
J8B	Terminal Post Black, 5 Way	Superior	DF30BC
K1	Relay - 4 PDT, 110V DC, 11K Coil	Potter Brumfield	KHP17D11
P1A	Connector Blue Ribbon	Amphenol	26-159-32
P1B	Connector Blue Ribbon	Amphenol	26-4100-32P
P1C	Connector Blue Ribbon	Amphenol	26-4100-24P
R2	Resistor, Dep. Carbon 24K, 1%, 1/2W	IRC	RN20X
R3	Resistor, Dep. Carbon 24K, 1%, 1/2W	IRC	RN20X
R5	Resistor, Variable 5K, 4 Gang	Remanco	10012
R7	Resistor, Variable 2x20K Sine, 20K, Lin.	Remanco	10036
R8	Resistor, Variable 10K, 2W, 10%	Allen Bradley	JLU

ASSEM. 502445

8.8.1 Front Panel - Reference Designator Prefix 1A7 (cont'd)
Model 902DK

REF. DESIG.	COMPONENT DESCRIPTION	MANUFACTURER	PART NO.
R9	Resistor, Variable 10K & 10K, 3%, 3T	Remanco	10050
R12	Resistor, Fixed Comp. 22 ohm, 5%, 1W	Allen Bradley	GB
R13	Resistor, Fixed Comp 1.5K, 5%, 1/2W	Allen Bradley	EB
R14	Resistor, Fixed Comp. 18K, 5%, 2W	Allen Bradley	HB
R58	Resistor, Fixed Wirewound 30K, 5%, 5W	Sprague	243E3035
R59	Resistor, Variable 250 ohm, 2W, 10%	Allen Bradley	JLU
R60	Resistor, Fixed Comp 510 ohm, 5%, 1/2W	Allen Bradley	EB
R64	Resistor, Fixed Comp 82K, 5%, 1W	Allen Bradley	GB
R65	Resistor, Fixed Comp 82K, 5%, 1W	Allen Bradley	GB
R66	Resistor, Fixed Comp 82K, 5%, 1W	Allen Bradley	GB
R67	Resistor, Fixed Comp 10 ohm, 5%, 1/2W	Allen Bradley	EB
R76	Resistor, Variable 5K, 2W, 10%	Allen Bradley	JLU
R77	Resistor, Fixed Wirewound, 60K, 1%, 5W	Dale	RS-5
R80	Resistor, Fixed Comp 1.15K, 1%, 1/4W	IRC	MEB-TO

8.8.1 Front Panel - Reference Designator Prefix 1A7 (cont'd)
Model 902DK

REF. DESIG.	COMPONENT DESCRIPTION	MANUFACTURER	PART NO.
R81	Resistor, Fixed Comp Selected, 5%, 1/2W	Allen Bradley	EB
R82	Resistor, Met. Film 10K, 1%, 1/4W	IRC	MEB-TO
R83	Resistor, Met. Film 140K, 1%, 1W	IRC	MEF-TO
R84	Resistor, Variable 3.5K, 2W, 10%	Allen Bradley	JLU
R85	Resistor, Fixed Wire-wound, 17.5K, 1%, 5W	Dale	RS-5
R86	Resistor, Fixed Comp 820 ohm, 5%, 1W	Allen Bradley	GB
R87	Resistor, Fixed Comp 330K, 5%, 1/2W	Allen Bradley	EB
R88	Resistor, Variable 25K, 2W, 10%	Allen Bradley	JLU
R89	Resistor, Variable 1K, 2W, 10%	Allen Bradley	JLU
R90	Resistor, Variable 5M, 2W, 20%	Allen Bradley	JLU
R91	Resistor, Metallic Film 20.0K, 1%, 1/8W	IRC	MEA-TO
R92	Resistor, Metallic Film 20.5K, 1%, 1/8W	IRC	MEA-TO
R93	Resistor, Metallic Film 21.0K, 1%, 1/8W	IRC	MEA-TO

ASSEM. 502445

8.8.1 Front Panel - Reference Designator Prefix 1A7 (cont'd)
Model 902DK

REF. DESIG.	COMPONENT DESCRIPTION	MANUFACTURER	PART NO.
R94	Resistor, Metallic Film 21.0K, 1%, 1/8W	IRC	MEA-TO
R95	Resistor, Variable 1K, 2W, 10%	Allen Bradley	JLU
R96	Resistor, Metallic Film 210K, 1%, 1/2W	IRC	MEC-TO
R97	Resistor, Metallic Film 9.31K, 1%, 1/4W	IRC	MEB-TO
R98	Resistor, Fixed Comp 18K, 5%, 1W	Allen Bradley	GB
R99	Resistor, Fixed WW 25K, 5%, 5W	Sprague	243E2535
R100	Resistor, Fixed WW 30K, 5%, 5W	Sprague	243E3035
R102	Resistor, Fixed Comp 10K, 5%, 1/2W	Allen Bradley	EB
R103	Resistor, Fixed Comp 330 ohm, 5%, 1/2W	Allen Bradley	EB
S1	Switch, Toggle DPDT		ST22N
S2	Switch, Toggle DPDT		ST22N
S3	Switch, Rotary 9P, 2-5 Position	Centralab	PA2029
S4	Switch, Rotary 6P, 2-5 position	Centralab	PA2021
S5	Switch, Toggle DPDT		ST22N

8.8.1 Front Panel - Reference Designator Prefix 1A7 (cont'd)
Model 902DK

REF. DESIG.	COMPONENT DESCRIPTION	MANUFACTURER	PART NO.
S6	Switch, Toggle DPDT		ST22N
S7	Switch, Rotary 6P, 2-5 position	Centralab	PA2021
S8	Switch, Push Button SPDT Moment	Switchcraft	903
S9, S10	Switch, Rotary (Frequency switches assy with resistors)	Remanco	502455
S11	Switch, Rotary 6P, 2-5 Position	Centralab	PA2021
XDS3	Socket, Nixie	Burrough	HSK-112
XDS4	Socket, Nixie	Burroughs	HSK-112
XDS5	Socket, Nixie	Burroughs	HSK-112
XF1	Holder, Fuse 5A, 250V	Bussman	HKP
XF2	Holder, Fuse 5A, 250V	Bussman	HKP
XK1	Socket, Relay	Potter Brumfield	9HK1

ASSEM. 501996

8.8.2 Assembly Panel - Reference Designator Prefix 1A7
Model 903A

REF. DESIG.	COMPONENT DESCRIPTION	MANUFACTURER	PART NO.
A1	Assy - Carrier Plugin (60/400 cps)	Remanco	500437
C1	Capacitor, Elect 30 MF, 50V	C-D	NLW 30-50
C2A	Capacitor, Mylar 10MF, 200V, 2%	Remanco	C100522
C2B	Capacitor, Mylar 10MF, 200V, 2%	Remanco	C100522
C3A	Capacitor, Mylar .1MF, 200V, 2%	Remanco	C100322
C3B	Capacitor, Mylar .1MF, 200V, 2%	Remanco	C100322
C4	Capacitor, Mylar .02MF, 300V, 2%	Remanco	C200232
C5	Capacitor, Mylar 3.17MF, 200V, 1%	Remanco	C317421
C6	Capacitor, Mylar .316MF, 200V, 1%	Remanco	C316321
C7	Capacitor, Mylar .0316MF, 200V, 1%	Remanco	C316221
C8	Capacitor, Mylar 3.17MF, 200V, 1%	Remanco	C317421
C9	Capacitor, Mylar .316MF, 200V, 1%	Remanco	C316321
C10	Capacitor, Mylar .0316MF, 200V, 1%	Remanco	C316221
C11	Capacitor, Mylar 3.17MF, 200V, 1%	Remanco	C317421

ASSEM. 501996

8.8.2 Assembly Panel - Reference Designator Prefix 1A7 (cont'd)
Model 903A

REF. DESIG.	COMPONENT DESCRIPTION	MANUFACTURER	PART NO.
C12	Capacitor, Mylar .316MF, 200V, 1%	Remanco	C316321
C13	Capacitor, Mylar .0316MF, 200V, 1%	Remanco	C316221
C14	Capacitor, Mylar 3.17MF, 200V, 1%	Remanco	C317421
C15	Capacitor, Mylar .316MF, 200V, 1%	Remanco	C316321
C16	Capacitor, Mylar .0316MF, 200V, 1%	Remanco	C316221
C17	Capacitor, Sil Mica 100PF, 500V	Elmenco	CM-15E-101
C18A	Capacitor, Mylar 1.0MF, 200V, 2%	Remanco	C100422
C18B	Capacitor, Mylar 1.0MF, 200V, 2%	Remanco	C100422
DS1	Assy. Neon Lamp 115V, 68K	Eldema	1EG3-6055
DS2	Assy. Neon Lamp 115V, 68K	Eldema	1EG3-6055
F1	Fuse, (115V) 4A, 3AG, Slo Blo	Littelfuse	313004
F1	Fuse, (230V) 2A, 3AG, Slo Blo	Littelfuse	313002
F2	Fuse, (115V) 3A, 3AG, Slo Blo	Littelfuse	313003
F2	Fuse, (230V) 1.5A, 3AG, Slo Blo	Littelfuse	31301.5

ASSEM. 501996

8.8.2 Assembly Panel - Reference Designator Prefix 1A7 (cont'd)
Model 903A

REF. DESIG.	COMPONENT DESCRIPTION	MANUFACTURER	PART NO.
J2	Socket - 9 Pin Min. Mica	Elco	TS103P03
J3	Terminal Post 5-Way, Red	Superior	DF30RC
J4A	Terminal Post 5-Way, Red	Superior	DF30RC
J4B	Terminal Post 5-Way, Black	Superior	DF30BC
J5A	Terminal Post 5-Way, Red	Superior	DF30RC
J5B	Terminal Post 5-Way, Red	Superior	DF30RC
J6A	Terminal Post 5-Way, Red	Superior	DF30RC
J6B	Terminal Post 5-Way, Black	Superior	DF30BC
J7A	Termimal Post 5-Way, Red	Superior	DF30RC
J7B	Terminal Post 5-Way Black	Superior	DF30BC
J8A	Terminal Post 5-Way, Red	Superior	DF30RC
J8B	Terminal Post 5-Way, Black	Superior	DF30BC
K1	Relay, 4PDT 110V DC, 11K Coil	Potter Brumfield	KHP17D11

ASSEM. 501996

8.8.2 Assembly Panel - Reference Designator Prefix 1A7
Model 903A

REF. DESIG.	COMPONENT DESCRIPTION	MANUFACTURER	PART NO.
P1A	Connector Blue Ribbon	Amphenol	26-159-32
P1B	Connector Blue Ribbon	Amphenol	26-4100-32P
P1C	Connector Blue Ribbon	Amphenol	26-4100-24P
R1	Resistor, Var. WW 4 x 500K Linear	Remanco	10041
R2	Resistor, Dep. Carb. 24K, 1%, 1/2W	IRC	RN20X
R3	Resistor, Dep. Carb. 24K, 1%, 1/2W	IRC	RN20X
R5	Resistor, Var. Comp. 4 x 5K Linear	Remanco	10012
R6	Resistor, Var. Comp. 500 ohm, 10%, 2W	Allen Bradley	JLU
R7	Resistor, Var. WW 2 x 20K Sin & 20K Lin	Remanco	10036
R8	Resistor, Var. Comp 10K, 10%, 2W	Allen Bradley	JLU
R9	Resistor, Var. WW 10K & 10K 3%, 3T	Remanco	10050
R10	Resistor, Var. WW 30K & 2.5K	Remanco	10047
R11	Resistor, Var. Comp. 25K, 10%, 2W	Allen Bradley	JLU

ASSEM. 501996

8.8.2 Assembly Panel - Reference Designator Prefix 1A7 (cont'd)
Model 903A

REF. DESIG.	COMPONENT DESCRIPTION	MANUFACTURER	PART NO.
R12	Resistor, Fixed Comp. 22 ohm, 5%, 1W	Allen Bradley	GB
R13	Resistor, Fixed Comp. 1.5K, 5%, 1/2W	Allen Bradley	EB
R14	Resistor, Fixed Comp. 18K, 5%, 2W	Allen Bradley	HB
R15	Resistor, Met. Film 24.9K, 1%, 1/2W	IRC	MEC-TO
R16	Resistor, Met. Film 24.9K, 1%, 1/2W	IRC	MEC-TO
R17	Resistor, Met. Film 24.9K, 1%, 1/2W	IRC	MEC-TO
R18	Resistor, Met. Film 24.9K, 1%, 1/2W	IRC	MEC-TO
R37	Resistor, Mold Carb. 2.49M, 1%, 1/2W	IRC	MDC
R57	Resistor, Var. Comp. 2.5K, 10%, 2W	Allen Bradley	JLU
R58	Resistor, Fixed Comp 43K, 5%, 2W	Allen Bradley	HB
R60	Resistor, Fixed Comp 1K, 5%, 1/2W	Allen Bradley	EB
R61	Resistor, Fixed Comp. 1.8K, 5%, 1W	Allen Bradley	GB
R62	Resistor, Var Comp. 1K, 10%, 2W	Allen Bradley	JLU
R63	Resistor, Fixed WW 20K, 1%, 5W	Dale	RS-5

8.8.2 Assembly Panel - Reference Designator Prefix 1A7 (cont'd)
Model 903A

REF. DESIG.	COMPONENT DESCRIPTION	MANUFACTURER	PART NO.
R67	Resistor, Met. Film 249K, 1/2%, 1/4W	IRC	CEB-TO
R76	Resistor, Var. Comp. 5K, 10%, 2W	Allen Bradley	JLU
R77	Resistor, Fixed WW 60K, 1%, 5W	Dale	RS-5
R80	Resistor, Met. Film 1.15K, 1%, 1/4W	IRC	MEB-TO
R81	Resistor, Fixed Comp (Selected) 5%, 1/2W	Allen Bradley	EB
R82	Resistor, Met. Film 10K, 1%, 1/4W	IRC	MEB-TO
R83	Resistor, Met. Film 140K, 1%, 1W	IRC	MEF-TO
R84	Resistor, Var. Comp. 3.5K, 10%, 2W	Allen Bradley	JLU
R85	Resistor, Fixed WW 17.5K, 1%, 5W	Dale	RS-5
R86	Resistor, Fixed Comp. 820 ohm, 5%, 1W	Allen Bradley	GB
R87	Resistor, Fixed Comp 330K, 5%, 1/2W	Allen Bradley	EB
R88	Resistor, Var. Comp. 25K, 10%, 2W	Allen Bradley	JLU
R89	Resistor, Var. Comp 1K, 10%, 2W	Allen Bradley	JLU

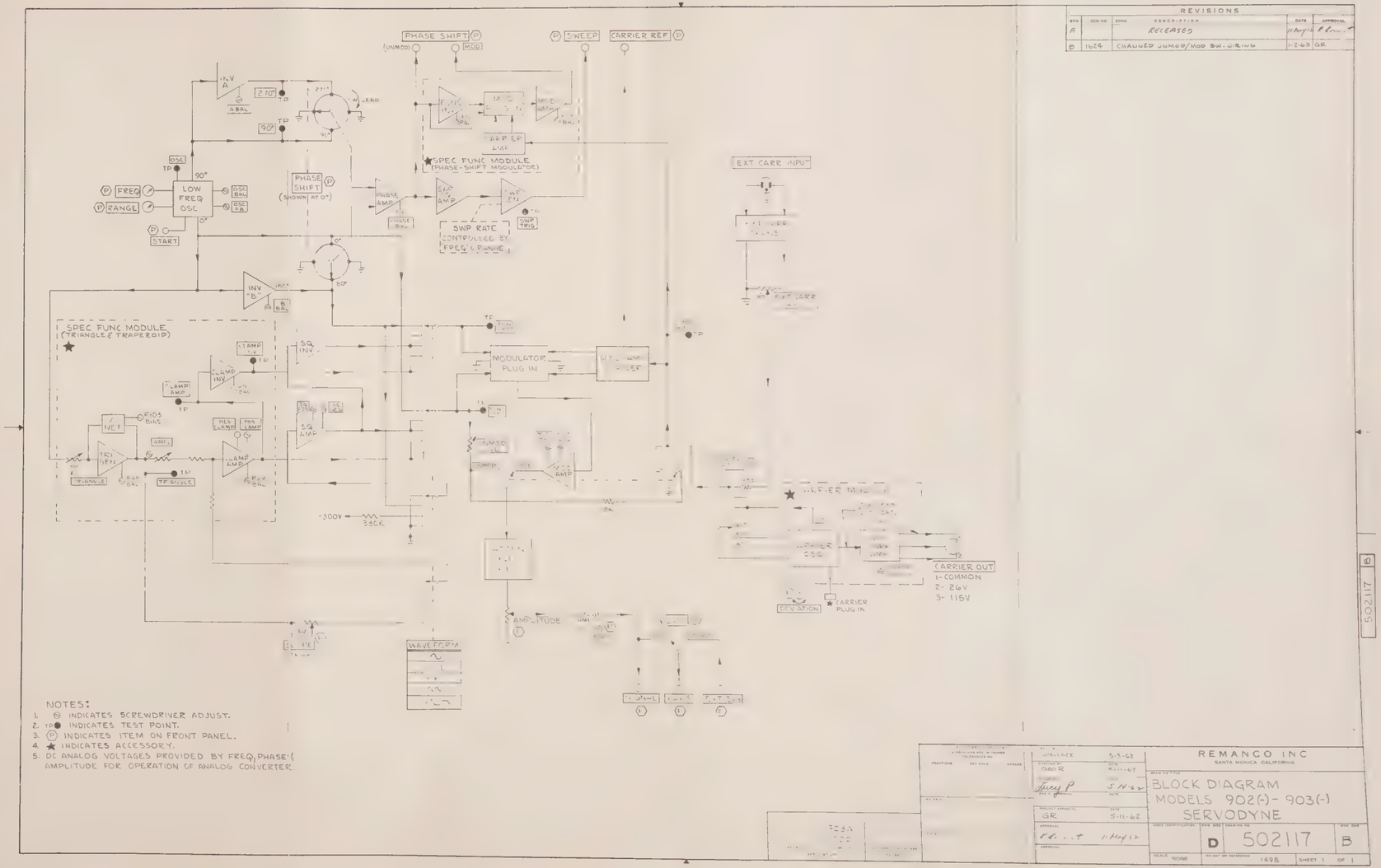
ASSEM. 501996

8.8.2 Assembly Panel - Reference Designator Prefix 1A7 (cont'd)
Model 903A

REF. DESIG.	COMPONENT DESCRIPTION	MANUFACTURER	PART NO.
R90	Resistor, Var. Comp 5 Meg, 20%, 2W	Allen Bradley	JLU
R91	Resistor, Met. Film 20.0K, 1%, 1/8W	IRC	MEA-TO
R92	Resistor, Met. Film 20.5K, 1%, 1/8W	IRC	MEA-TO
R93	Resistor, Met. Film 21.0K, 1%, 1/8W	IRC	MEA-TO
R94	Resistor, Met. Film 21.0K, 1%, 1/8W	IRC	MEA-TO
R95	Resistor, Variable 1K, 10%, 2W	Allen Bradley	JLU
R96	Resistor, Met. Film 22.1K, 1%, 1/2W	IRC	MEC-TO
R97	Resistor, Met. Film 9.31K, 1%, 1/4W	IRC	MEB-TO
R98	Resistor, Fixed Comp 18K, 5%, 1W	Allen Bradley	GB
R101	Resistor, Met. Film 187K, 1%, 1/2W	IRC	MEC-TO
R102	Resistor, Fixed Comp 10K, 5%, 1/2W	Allen Bradley	EB
R103	Resistor, Fixed Comp 330 ohm, 5%, 1/2W	Allen Bradley	EB
S1	Switch, Toggle DPDT		ST22N

8.8.2 Assembly Panel - Reference Designator Prefix 1A7 (cont'd)
Model 903A

REF. DESIG.	COMPONENT DESCRIPTION	MANUFACTURER	PART NO.
S2	Switch, Toggle DPDT		ST22N
S3	Switch, Rotary 9-Pole, 2-5 Pos.	CRL	PA-2029
S4	Switch, Rotary 6-Pole, 2-5 Pos.	CRL	PA-2021
S5	Switch, Toggle DPDT		ST22N
S6	Switch, Toggle DPDT		ST22N
S7	Switch, Rotary 6-Pole, 2-5 Pos.	CRL	PA-2021
S8	Switch, Push Button SPDT Moment	Switchcraft	903
S11	Switch, Rotary 6-Pole, 2-5 Pos.	CRL	PA-2021
TP1	Jack Tip White	E.F. Johnson	105-201-200
XF1	Holder - Fuse 5A 250V	Bussman	HKP
XF2	Holder - Fuse 5A 250V	Bussman	HKP
XK1	Socket - Relay 14 Pin	Potter Brumfield	9HK1



NOTES:
1. ⊖ INDICATES SCREWDRIVER ADJUST.
2. TP● INDICATES TEST POINT.
3. (P) INDICATES ITEM ON FRONT PANEL.
4. ★ INDICATES ACCESSORY.
5. DC ANALOG VOLTAGES PROVIDED BY FREQ, PHASE & AMPLITUDE FOR OPERATION OF ANALOG CONVERTER.

REVISIONS

BY	ECO NO	ZONE	DESCRIPTION	DATE	APPROVAL
A			RELEASED	11 May 62	
B	1624		CHANGED SYNMOD/MOD SW. WIRING	1-24-63	GR

DRAWN	WALLACE	5-3-62
CHECKED	GEO R	5-11-62
ENGINEER		5-14-62
PROJECT ENGINEER	GR	5-11-62
APPROVED		11 May 62
APPROVED		

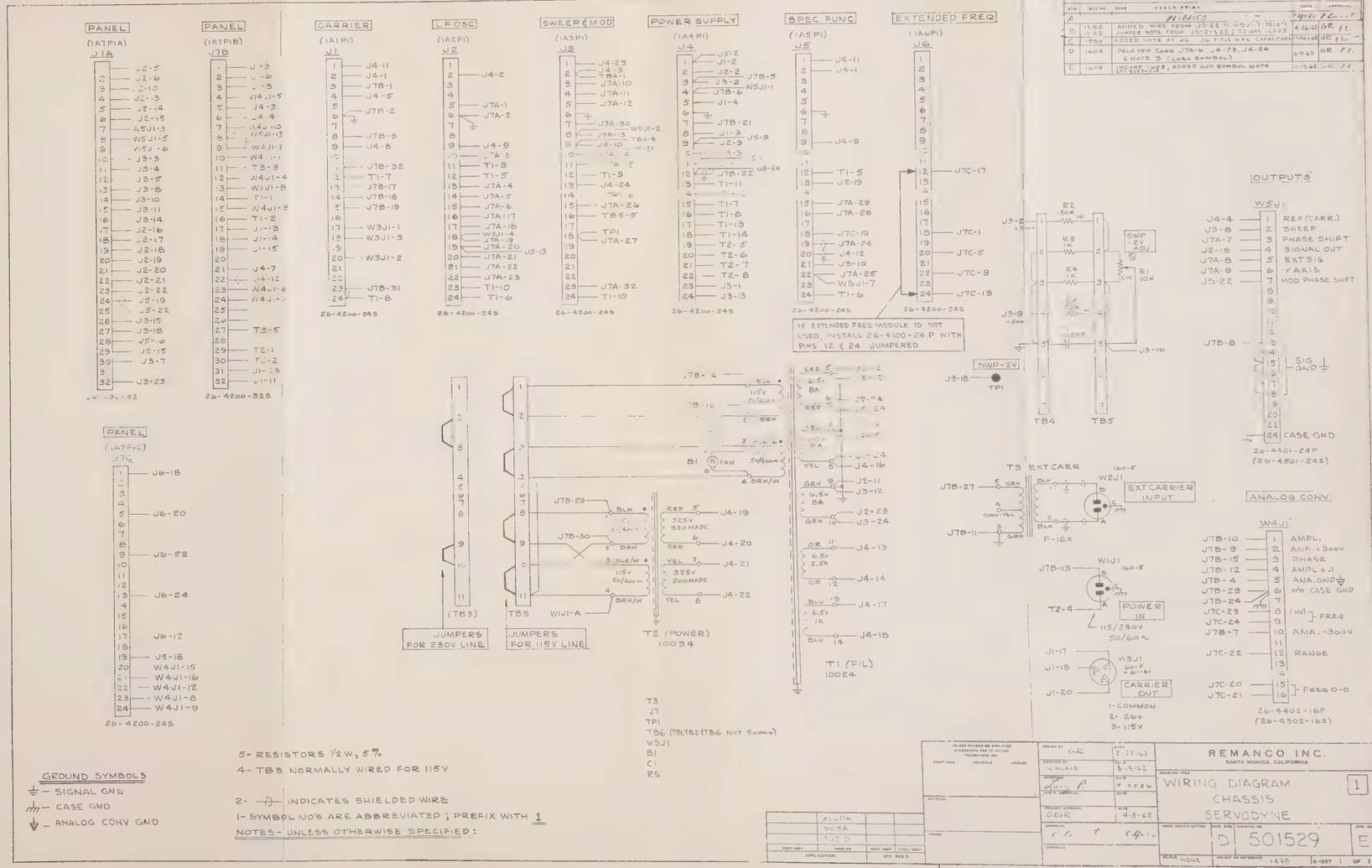
REMANCO INC
SANTA MONICA CALIFORNIA

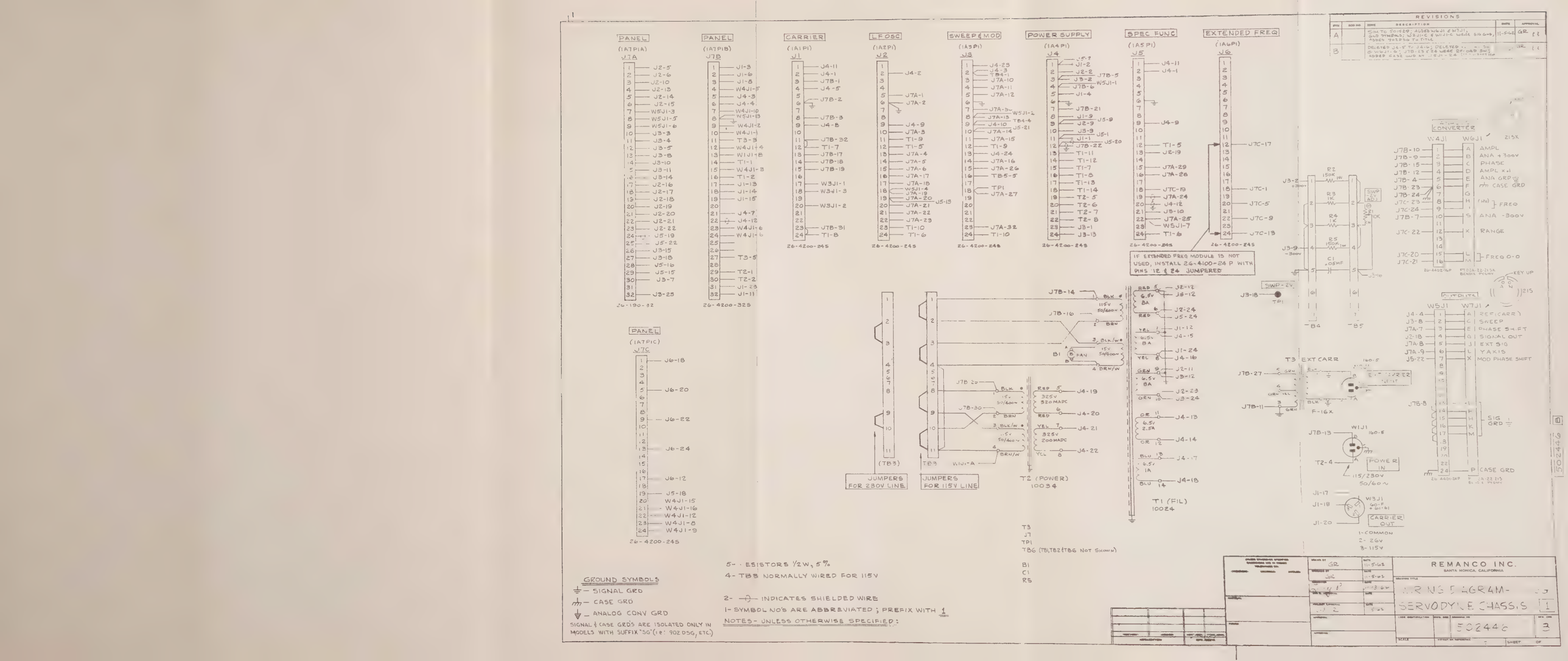
BLOCK DIAGRAM
MODELS 902(-) - 903(-)
SERVODYNE

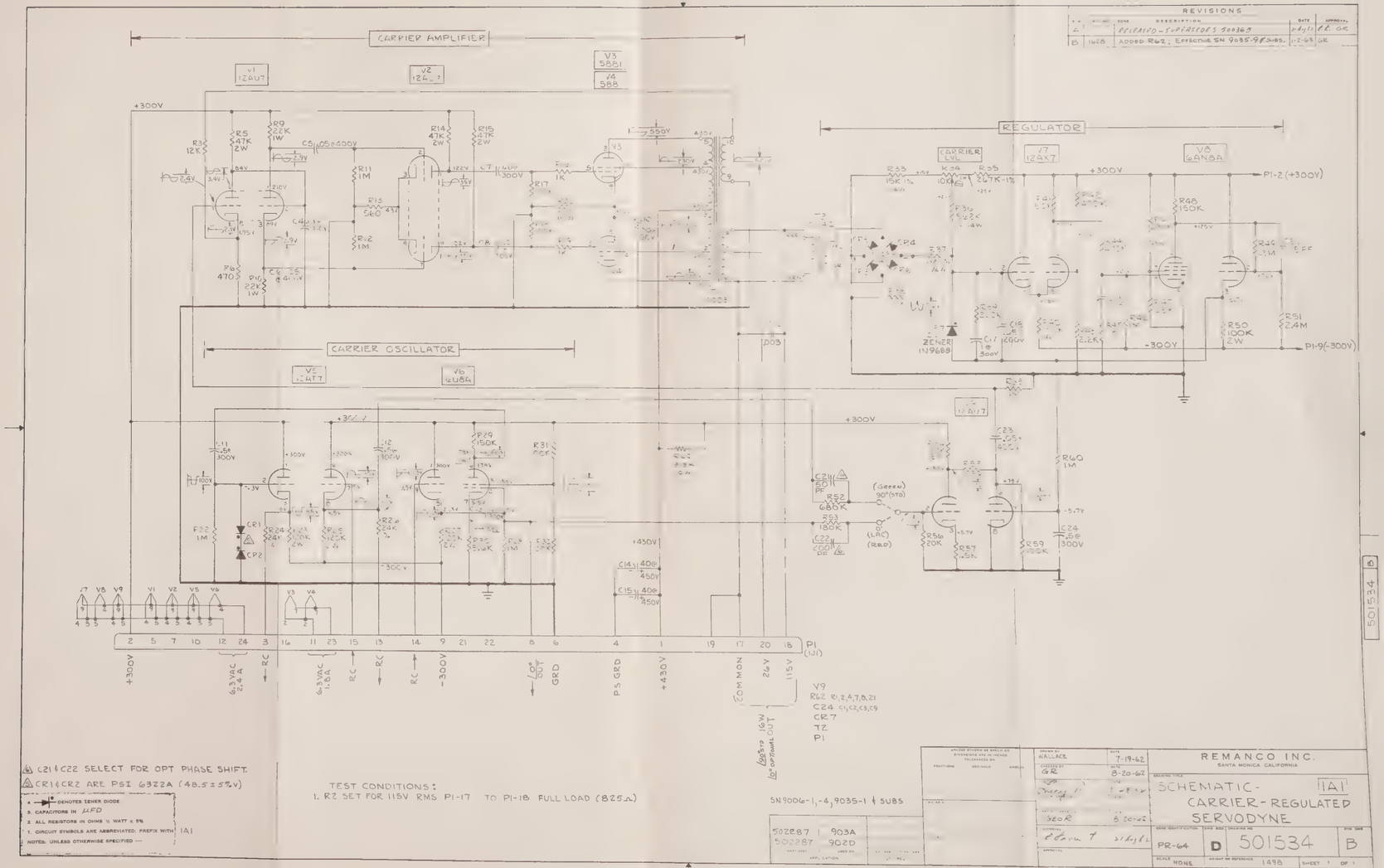
D 502117 B

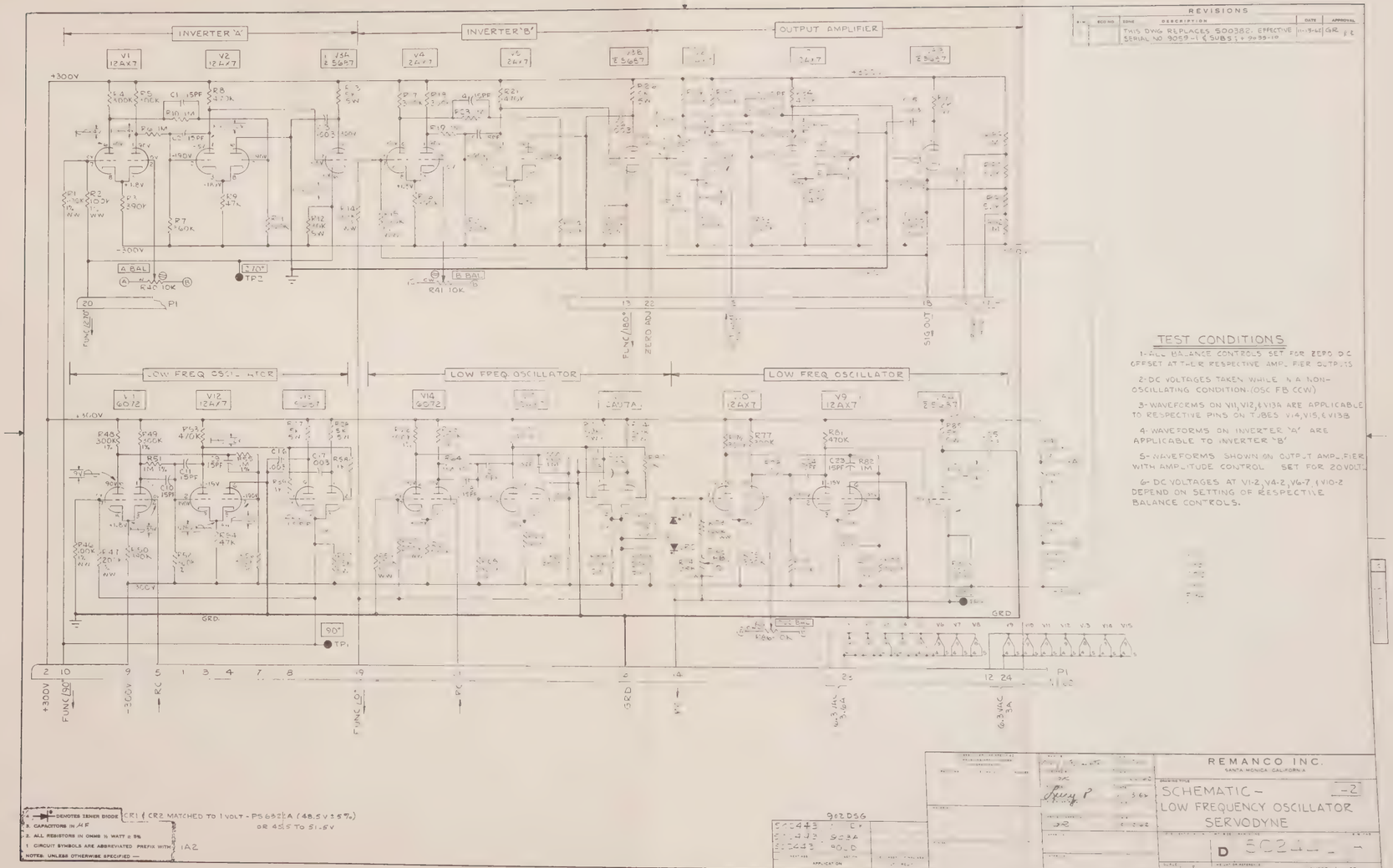
SCALE NONE | 1498 | SHEET 1 OF 1

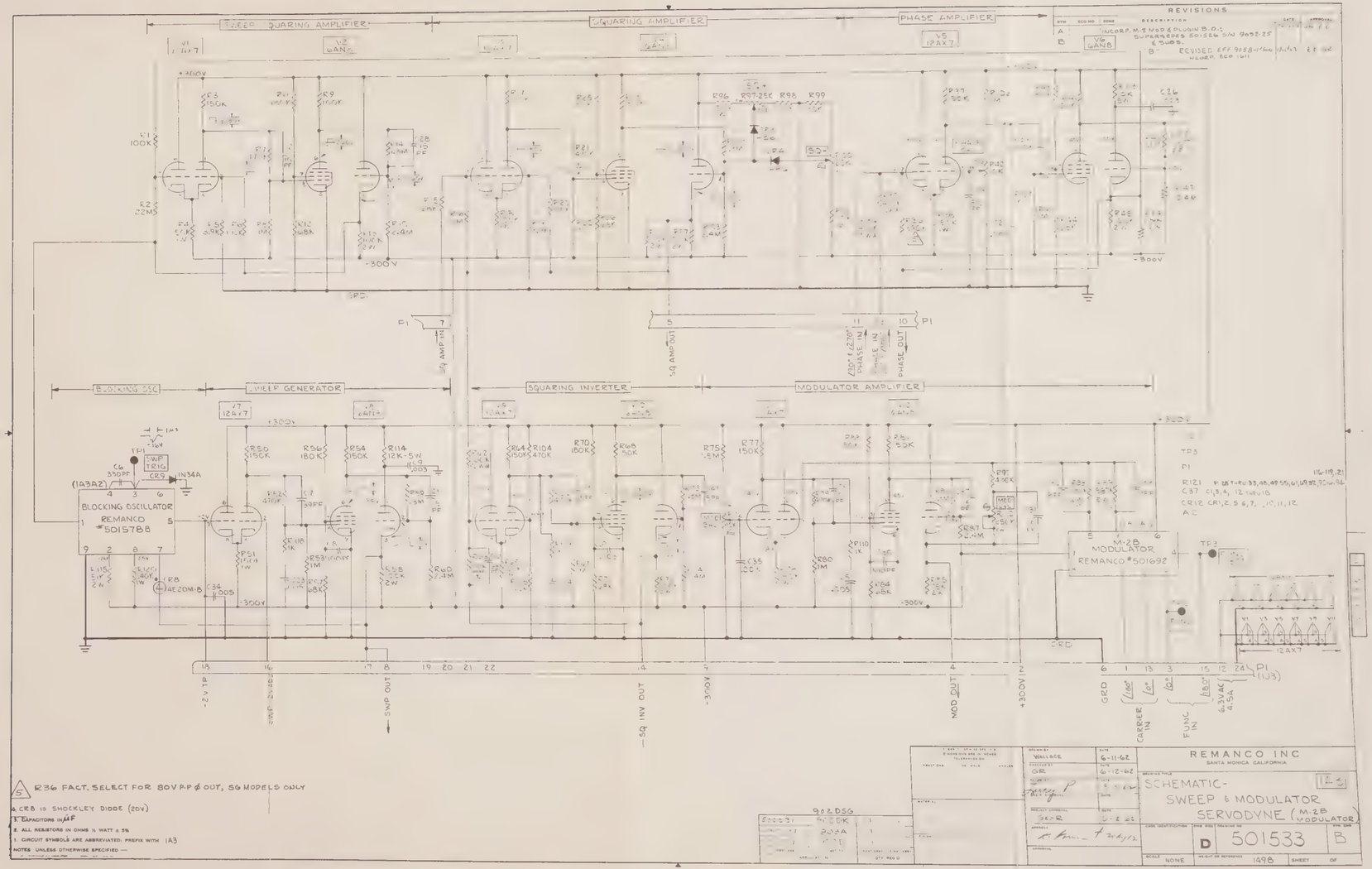
502117 B


PANEL (1A7P1A) J1A
PANEL (1A7P1B) J7B
CARRIER (1A1P1) J1
LFOSC (1A2P1) J2
SWEEP & MOD (1A3P1) J3
POWER SUPPLY (1A4P1) J4
SPEC FUNC (1A5P1) J5
EXTENDED FREQ (1A6P1) J6
26-4200-245
26-4200-325
IF EXTENDED FREQ MODULE IS NOT USED, INSTALL 26-4100-24 P WITH PINS 12 & 24 JUMPERED
PANEL (1A7P1C) J7C
26-4200-245
JUMPERS FOR 230V LINE
JUMPERS FOR 115V LINE
TB3
W1J1-A
T2 (POWER) 10034
T1 (FIL) 10024
T3
J7
TP1
TB6 (TB1, TB2 & TB6 NOT SHOWN)
W5J1
B1
C1
R5
GROUND SYMBOLS
⏚ — SIGNAL GND
⏚ — CASE GND
⏚ — ANALOG CONV GND
5- RESISTORS 1/2W, 5%
4- TB3 NORMALLY WIRED FOR 115V
2- —O— INDICATES SHIELDED WIRE
1- SYMBOL NO'S ARE ABBREVIATED ; PREFIX WITH 1
NOTES- UNLESS OTHERWISE SPECIFIED:
OUTPUTS
W5J1
J4-4 REF(CARR.)
J3-8 SWEEP
J7A-7 PHASE SHIFT
J2-18 SIGNAL OUT
J7A-8 EXT SIG
J7A-9 Y AXIS
J5-22 MOD PHASE SHIFT
J7B-8
SIG GND
CASE GND
26-4401-24P
(26-4501-245)
SWP -2V ADJ
R2 150K
R3 1K
R4 1K
R1 10K
TB4
TB5
J3-16
J3-18
TP1
T3 EXT CARR 160-5
W2J1
EXT CARRIER INPUT
F-16X
ANALOG CONV.
W1J1
AMPL.
ANA. +300V
PHASE
AMPL. ret
ANA. GND
CASE GND
(-1W)
ANA. -300V
RANGE
FREQ
FREQ 0-0
26-4402-16P
(26-4502-165)
W1J1 160-5
T2-4
POWER IN
115/230V 50/60~
J1-17
J1-18
J1-20
W3J1 160-F & 61-61
CARRIER OUT
1- COMMON
2- 26V
3- 115V
REMANCO INC.
SANTA MONICA, CALIFORNIA
WIRING DIAGRAM
CHASSIS
SERVODYNE
1
D 501529
E
SCALE NONE
SHEET 1 OF 1
DRAWN GR 2-22-62
CHECKED W. BLAKE 3-15-62
ENGINEER 4-25-62
PROJECT ENGINEER GEOR 4-5-62
REVISIONS
A — RELEASED — 4-26-62 GR
B — ADDED WIRE FROM J5-22 TO W5J1-7, DELETE JUMPER NOTE FROM J5-21 & 22, J2 WAS 16 PIN — 4-26-62 GR
C — ADDED NOTE AT J6, J6 TITLE WAS CAPACITORS — 11-19-62 GR
D — DELETED COAX J7A-6, -4-23, J4-24 & NOTE 3 (COAX SYMBOL) — 6-9-62 GR
E — ADDED J1-17, J1-18, J1-20 & ADDED GND SYMBOL NOTE — 11-19-62 GR

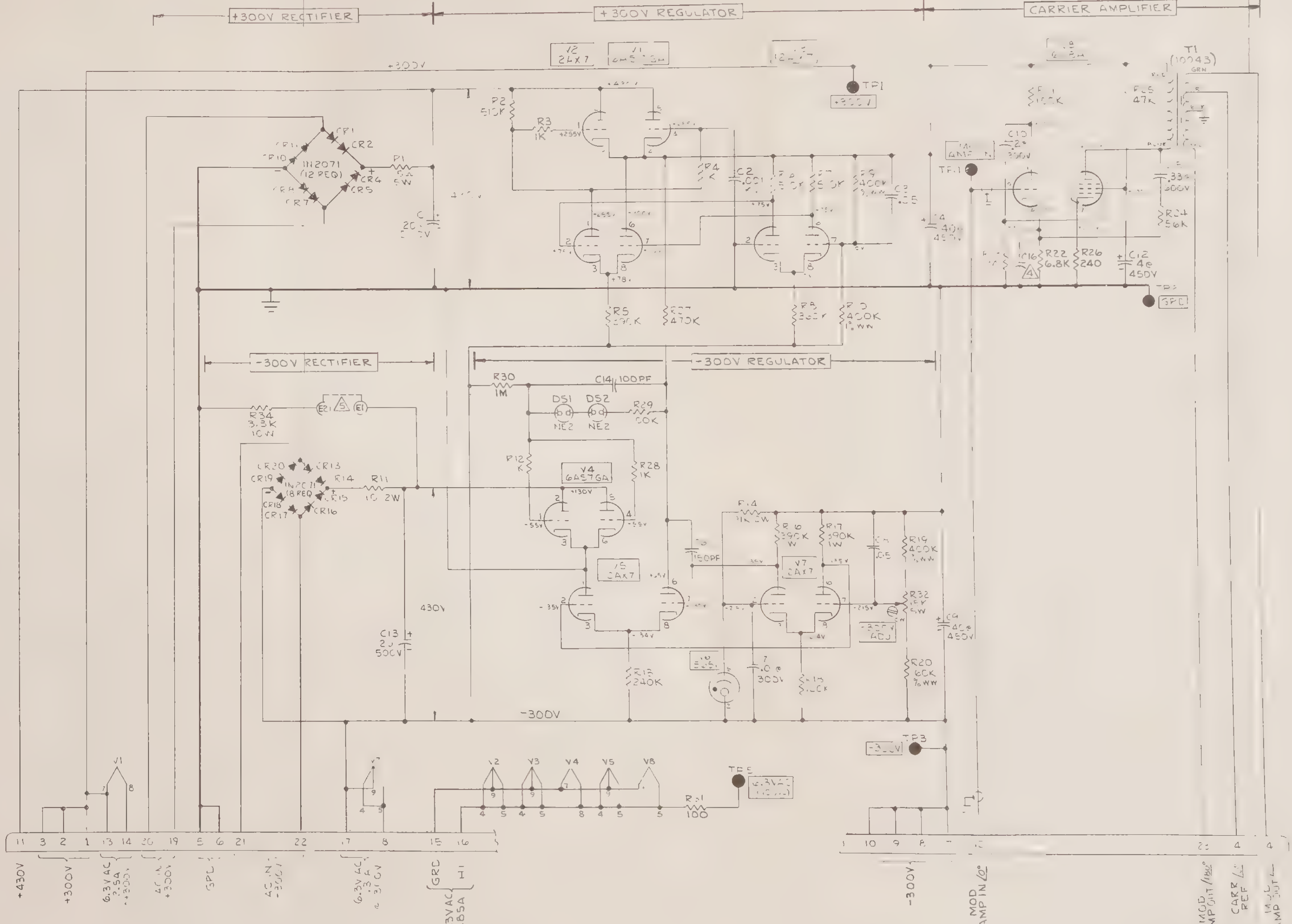

REVISIONS
PANEL (1A1P1A) J7A
PANEL (1A1P1B) J7B
CARRIER (1A1P1)
LF OSC (1A2P1)
SWEEP & MOD (1A3P1)
POWER SUPPLY (1A4P1)
SPEC FUNC (1A5P1)
EXTENDED FREQ (1A6P1)
26-4200-245
26-4200-325
26-190-32
PANEL (1A1P1C) J7C
IF EXTENDED FREQ MODULE IS NOT USED, INSTALL 26-4100-24 P WITH PINS 12 & 24 JUMPERED
CONVERTER
W4J1
W6J1
215X
AMPL
ANA +300V
PHASE
AMPL x.1
ANA GRD
CASE GRD
(1N) FREQ
ANA -300V
RANGE
FREQ 0-0
KEY UP
MODULE
W5J1
W7J1
REF(CARR)
SWEEP
PHASE SHIFT
SIGNAL OUT
EXT SIG
Y AXIS
MOD PHASE SHIFT
SIG GRD
CASE GRD
JUMPERS FOR 230V LINE
JUMPERS FOR 115V LINE
T2 (POWER) 10034
T1 (FIL) 10024
T3 EXT CARR
F-16X
POWER IN 115/230V 50/60~
CARRIER OUT
1-COMMON
2- 26V
3-115V
T3
J7
TP1
TB6 (TB1,TB2 &TB6 NOT SHOWN)
B1
C1
R5
GROUND SYMBOLS
— SIGNAL GRD
— CASE GRD
— ANALOG CONV GRD
SIGNAL & CASE GRDS ARE ISOLATED ONLY IN MODELS WITH SUFFIX "SG" (i.e: 902 DSG, ETC.)
5- · ESISTORS 1/2W, 5%
4- TBB NORMALLY WIRED FOR 115V
2- INDICATES SHIELDED WIRE
1- SYMBOL NO'S ARE ABBREVIATED ; PREFIX WITH 1
NOTES- UNLESS OTHERWISE SPECIFIED :
REMANCO INC.
SANTA MONICA, CALIFORNIA
SERVODYNE CHASSIS
502446


REVISIONS
LTR | ECN NO. | ZONE | DESCRIPTION | DATE | APPROVAL
A | | | RELEASED - SUPERSEDES 500369 | 7-19-62 | GR
B | 1628 | | ADDED R62; EFFECTIVE SN 9035-9 & SUBS. | 12-6-63 | GR
CARRIER AMPLIFIER
CARRIER OSCILLATOR
REGULATOR
V1 12AU7
V2 12AT7
V3 5881
V4 5881
V5 12AT7
V6 6U8A
V7 12AX7
V8 6AN8A
V9 12AU7
+300V
-300V
+450V
-5.7V
CARRIER LVL
ZENER 1N9688
P1-2 (+300V)
P1-9 (-300V)
P1 (101)
+300V
63VAC 2.4A
63VAC 1.6A
RC
LO OUT
GRD
PS GRD
+430V
COMMON
26V
115V
LO OUT
16W
V9
R62
C24
CR7
T2
P1
C21 & C22 SELECT FOR OPT PHASE SHIFT.
CR1 & CR2 ARE PSI 6322A (48.5±5%V)
4 — DENOTES ZENER DIODE
3. CAPACITORS IN μFD
2. ALL RESISTORS IN OHMS ½ WATT ± 5%
1. CIRCUIT SYMBOLS ARE ABBREVIATED: PREFIX WITH 1A1
NOTES: UNLESS OTHERWISE SPECIFIED —
TEST CONDITIONS:
1. R2 SET FOR 115V RMS P1-17 TO P1-18 FULL LOAD (825Ω)
SN 9006-1, -4, 9035-1 & SUBS
502287 | 903A
502287 | 902D
DRAWN BY WALLACE 7-19-62
CHECKED BY GR 8-20-62
APPROVED 8-20-62
REMANCO INC.
SANTA MONICA CALIFORNIA
SCHEMATIC - CARRIER-REGULATED SERVODYNE
1A1
PR-64 D 501534 B
SCALE NONE
SHEET 1 OF 1
501534 B


REVISIONS
THIS DWG REPLACES 502382. EFFECTIVE SERIAL NO 9059-1 & SUBS 1 + 9059-129
INVERTER 'A'
INVERTER 'B'
OUTPUT AMPLIFIER
LOW FREQ OSCILLATOR
LOW FREQ OSCILLATOR
LOW FREQ OSCILLATOR
+300V
-300V
+150V
GRD
A BAL
R40 10K
R41 10K
TP2
TP1
P1
FUNC/180°
ZERO ADJ
SIG OUT
TEST CONDITIONS
1- ALL BALANCE CONTROLS SET FOR ZERO DC OFFSET AT THEIR RESPECTIVE AMPLIFIER OUTPUTS
2- DC VOLTAGES TAKEN WHILE IN A NON-OSCILLATING CONDITION. (OSC FB CCW)
3- WAVEFORMS ON V11, V12, & V13A ARE APPLICABLE TO RESPECTIVE PINS ON TUBES V14, V15, & V13B
4- WAVEFORMS ON INVERTER 'A' ARE APPLICABLE TO INVERTER 'B'
5- WAVEFORMS SHOWN ON OUTPUT AMPLIFIER WITH AMPLITUDE CONTROL SET FOR 20 VOLTS
6- DC VOLTAGES AT V1-2, V4-2, V6-7 (V10-2 DEPEND ON SETTING OF RESPECTIVE BALANCE CONTROLS.
DENOTES ZENER DIODE
CAPACITORS IN μF
ALL RESISTORS IN OHMS ½ WATT ± 5%
CIRCUIT SYMBOLS ARE ABBREVIATED. PREFIX WITH 1A2
NOTES: UNLESS OTHERWISE SPECIFIED —
CR1 & CR2 MATCHED TO 1 VOLT - PS6821A (48.5 V ± 5%) OR 45.5 TO 51.5 V
REMANCO INC.
SANTA MONICA CALIFORNIA
SCHEMATIC — -2
LOW FREQUENCY OSCILLATOR
SERVODYNE
D 502[illegible]


SWEEP SQUARING AMPLIFIER
SQUARING AMPLIFIER
PHASE AMPLIFIER
REVISIONS
BLOCKING OSC
SWEEP GENERATOR
SQUARING INVERTER
MODULATOR AMPLIFIER
BLOCKING OSCILLATOR REMANCO #501578
M-2B MODULATOR REMANCO #501692
+300V
-300V
SWP OUT
-SQ INV OUT
MOD OUT
CARRIER IN
FUNC IN
6.3VAC 4.5A
R36 FACT. SELECT FOR 80V P-P ϕ OUT, SQ MODELS ONLY
4. CR8 IS SHOCKLEY DIODE (20V)
3. CAPACITORS IN μF
2. ALL RESISTORS IN OHMS ½ WATT ± 5%
1. CIRCUIT SYMBOLS ARE ABBREVIATED. PREFIX WITH 1A3
NOTES UNLESS OTHERWISE SPECIFIED —
REMANCO INC
SANTA MONICA CALIFORNIA
SCHEMATIC-
SWEEP & MODULATOR
SERVODYNE (M-2B MODULATOR)
501533
D
B
SCALE NONE
SHEET OF

REVISIONS					
SYM	ECO NO	ZONE	DESCRIPTION	DATE	APPROVAL
H	1424		REDRAWN - ADDED R32, C15, DEL C11	5-1-62	GR R.K.
J			REF DESIGNATOR TP4 WAS TP5 & TP5 WAS TP4	4 JUNE 62	GR R.K.
K	1603		ADDED R33, 10, 2W	29 AUG 62	R.K. GR
L			DELETED C5, CR3, CR6, CR9 CR12, R33; ADDED NOTE 4 & 5, C16 R34; R1 WAS 10 Ω, 2W & C3 WAS 40MF 450V, EFFECTIVE S/N 9056-15 SUBS	19 OCT 62	GR R.K.



(1A3) P1 (AMPHENOL BLUE RIBBON 26-4100-24P)
(1J3)

R34
CR20 CR3 CR6 CR9 CR12
T1
TP5
DS2
P1

TEST CONDITIONS:
VOLTAGES SHOWN ARE WITH ALL MODULES IN OPERATION.

⚠5 CONNECT (E1) TO (E2) WHEN USING SF-1 MODULE (501984)

⚠4 C16: FACTORY SELECT FOR MIN PHASE SHIFT @ 5KC

3. CAPACITORS IN MFD
2. ALL RESISTORS IN OHMS ½ WATT ± 5%
1. CIRCUIT SYMBOLS ARE ABBREVIATED. PREFIX WITH 1A4

NOTES: UNLESS OTHERWISE SPECIFIED —

APPLICATION	9034
DRAWN BY	WALLACE
CHECKED BY	GR 5-3-62
	Lucy P 5-14-62
	GEO R
APPROVAL	R. Kovner 11 May 62

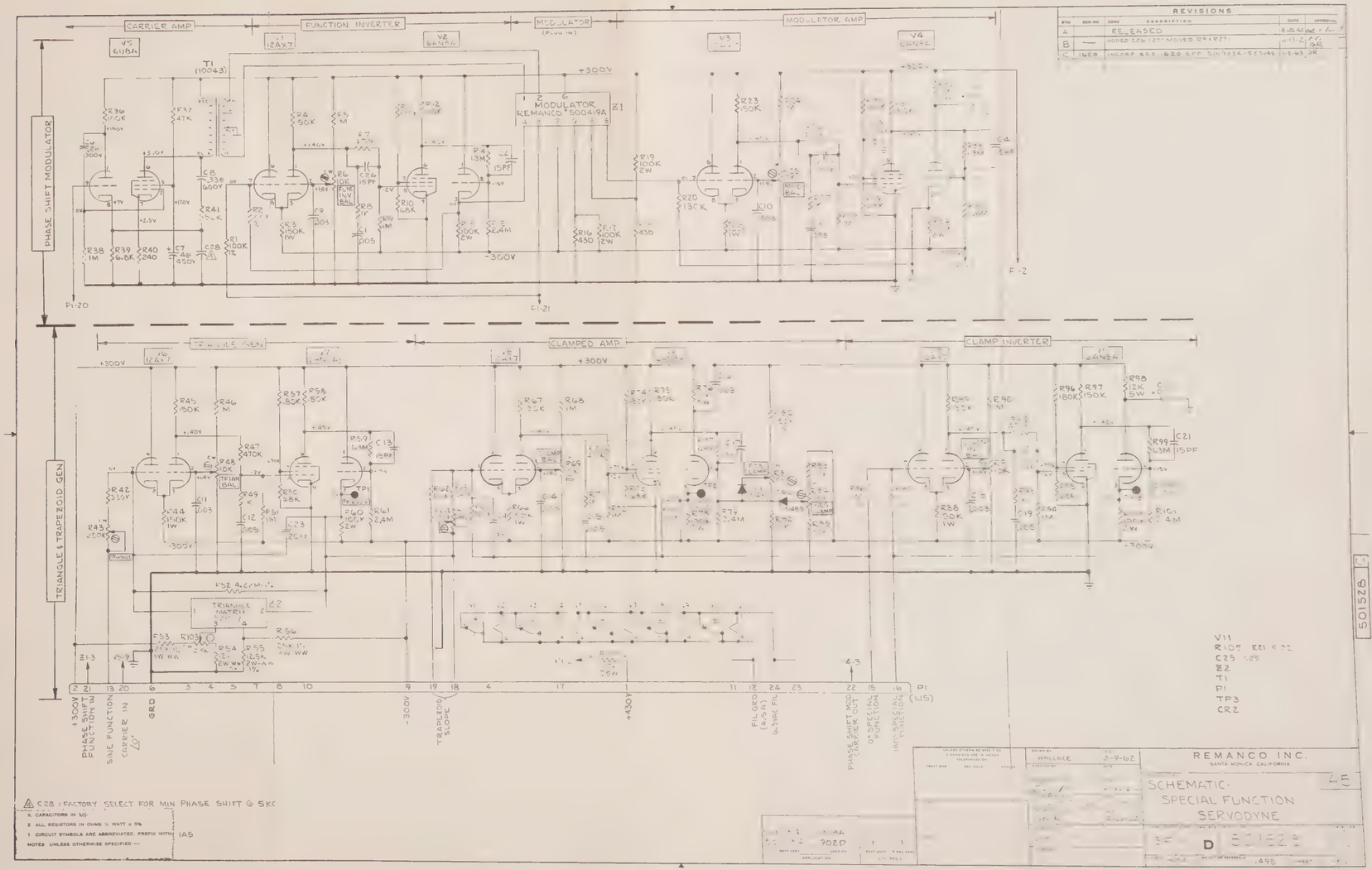
REMANCO INC.
SANTA MONICA CALIFORNIA

SCHEMATIC POWER SUPPLY SERVODYNE — 1A4

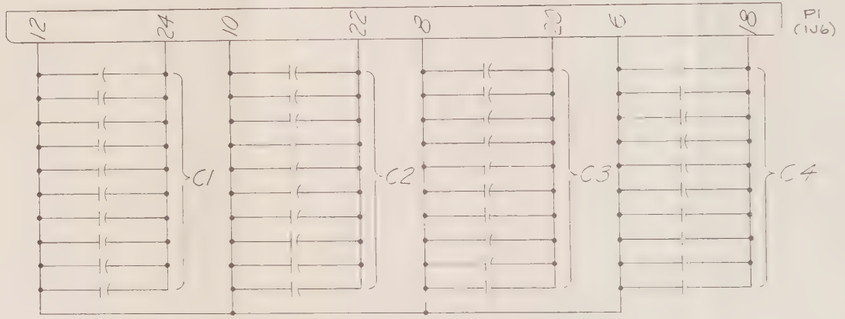
DWG SIZE	DRAWING NO	SYM CODE
D	500296	L

SCALE NONE — WEIGHT OR REFERENCE 1498 — SHEET OF

500296 L


CARRIER AMP
FUNCTION INVERTER
MODULATOR (PLUG IN)
MODULATOR AMP
PHASE SHIFT MODULATOR
TRIANGLE & TRAPEZOID GEN
CLAMPED AMP
CLAMP INVERTER
MODULATOR REMANCO 500419A
+300V
-300V
REVISIONS
RELEASED
INCORP ECO 620 EFF S/N 7034-5556AS
REMANCO INC.
SANTA MONICA CALIFORNIA
SCHEMATIC-
SPECIAL FUNCTION
SERVODYNE
SE D 501528
C28 : FACTORY SELECT FOR MIN PHASE SHIFT @ 5KC
NOTES UNLESS OTHERWISE SPECIFIED —
V11
R105 R21 R22
C25
Z2
T1
P1
TP3
CR2

REVISIONS				
LTR	ZONE	DESCRIPTION	DATE	APPROVED
A		TITLE WAS CAPACITOR MODULE	4-15-62	GR
B		NOTE 1 WAS 10 CAP. & 2 SNIFU	5-15-62	GR



3. REFERENCE - PA 501551
2. SYMBOLS ABBREVIATED - PREFIX WITH 1A6
1. CAPACITORS C1, C2, C3, C4, EACH CONSISTS OF CAPACITORS SELECTED TO TOTAL 31.7 MFD ±1%

NOTES: UNLESS OTHERWISE SPECIFIED

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UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ON FRACTIONS DECIMALS ANGLES

MATERIAL

DRAWN	D. McLAUGHLIN	2-12-62
CHECKED		
ENGINEER	Larry P	5-15-62
PROJECT APPROVAL	GR	5-15-62
APPROVAL		

REMANCO INC.
SANTA MONICA CALIFORNIA

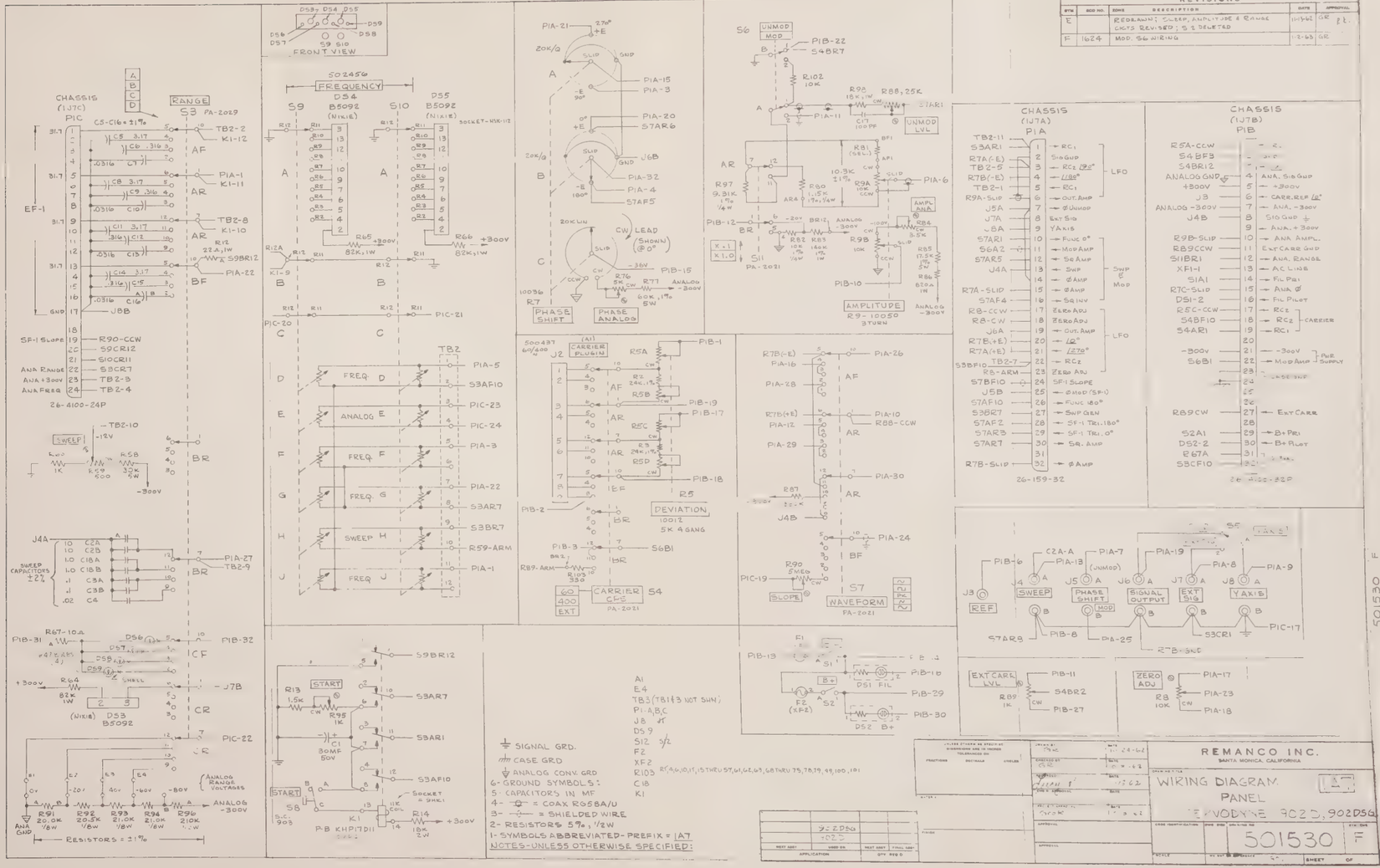
SCHEMATIC - 1A6
EXTENDED FREQ MODULE
SERVODYNE EF-1

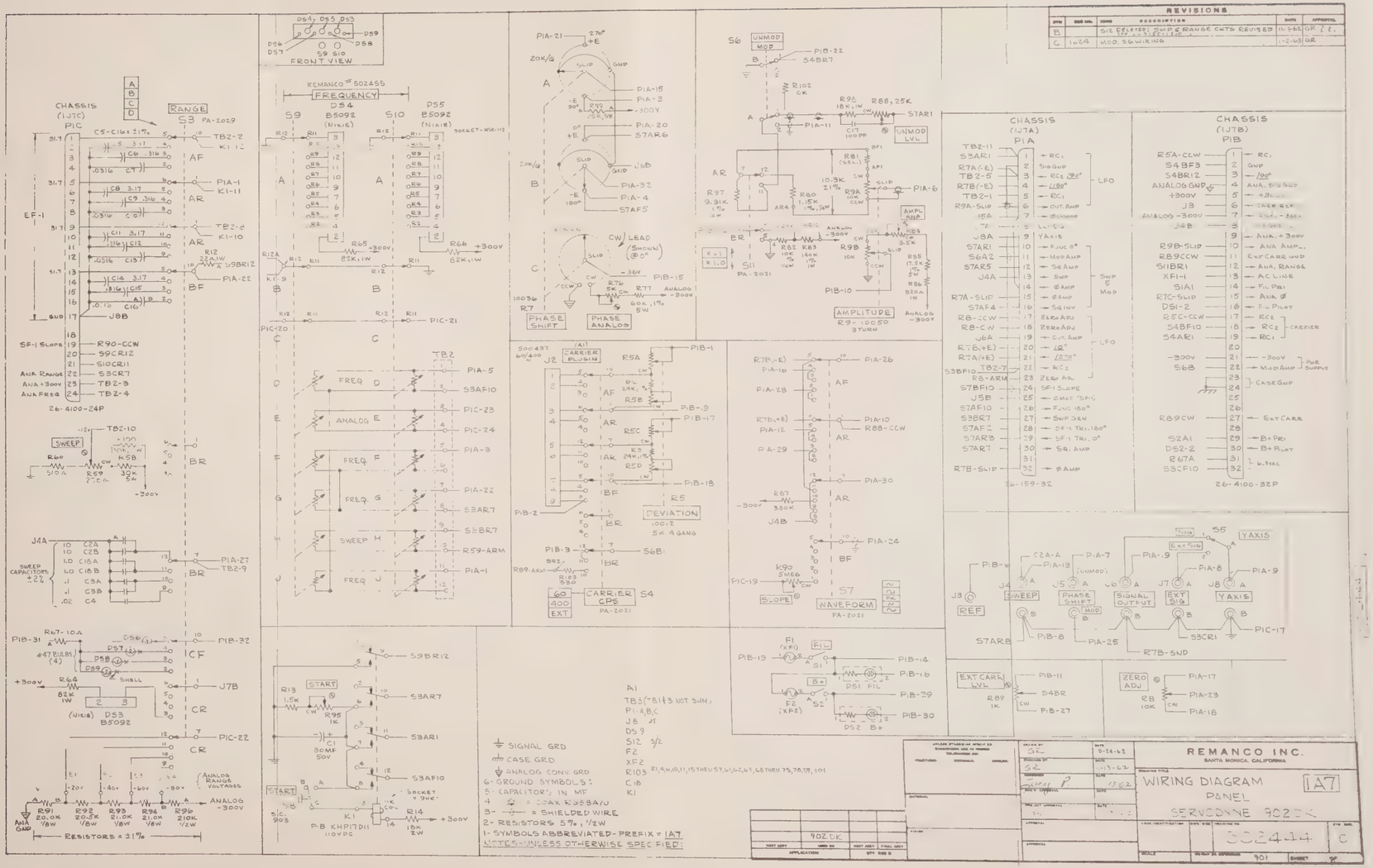
CODE IDENTIFICATION	SIZE	DRAWING NO	REV
	C	501551	B

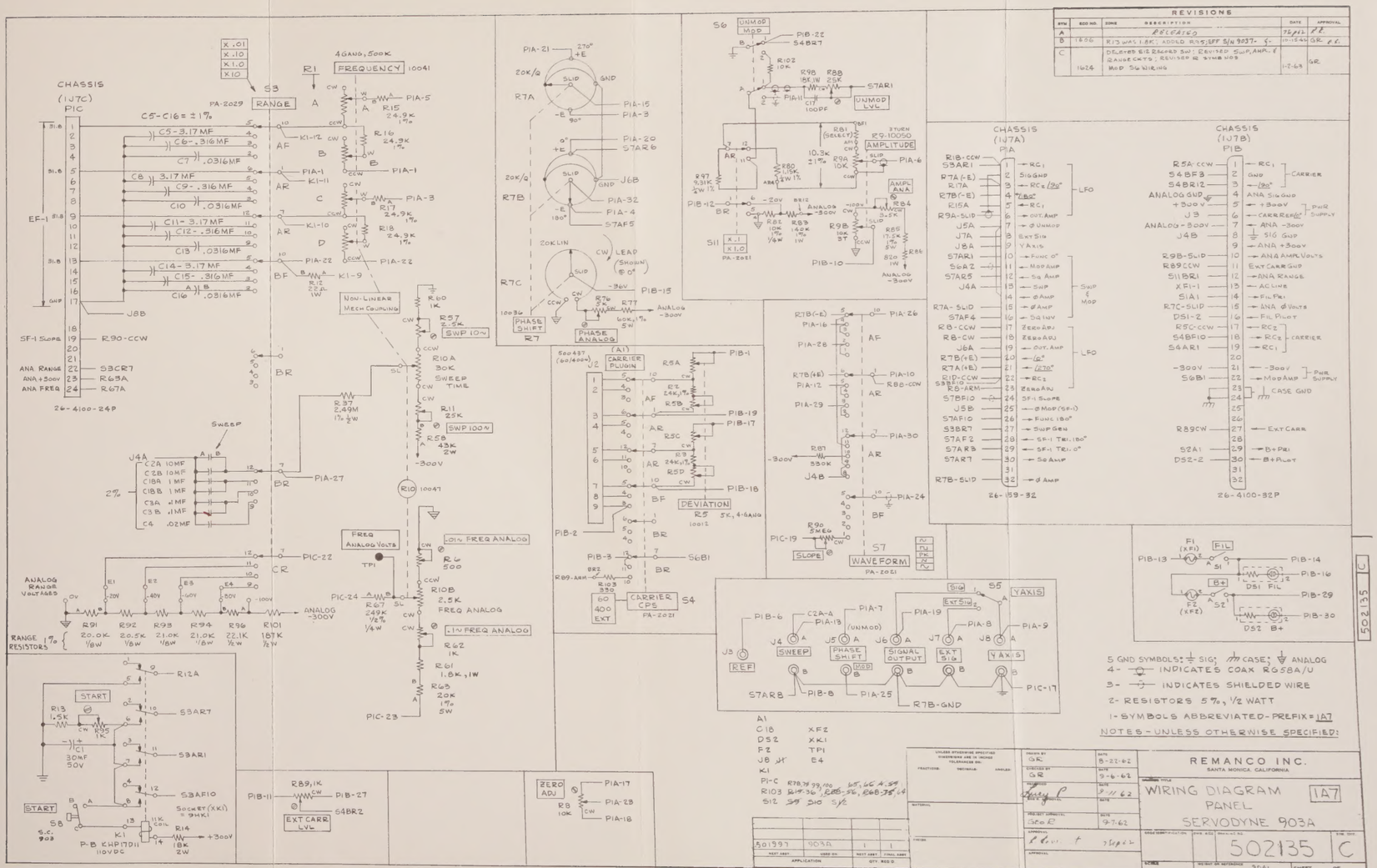
NEXT ASSY | USED ON | APPLICATION | DO NOT SCALE DRAWING | SHEET 1 OF 1

902DSG	902DK
501546	903A
501546	902D

501551


REVISIONS
ZONE DESCRIPTION DATE APPROVAL
REDRAWN; SWEEP, AMPLITUDE & RANGE CKTS REVISED; S 5 DELETED
MOD. SW WIRING
CHASSIS (1JTC) PIC
RANGE S3 PA-2029
TBZ-2 K1-12 AF
PIA-1 K1-11 AR
TBZ-8 K1-10 AR
S9BR12 PIA-22 BF
JBB
R90-CCW S9CR12 S10CR11 S3CR7 TBZ-3 TBZ-4
26-4100-24P
SWEEP
TBZ-10 -12V
R58 32K 5W -300V
BR
J4A SWEEP CAPACITORS ±2%
PIA-27 TBZ-9 BR
R67-10Ω
PIB-32 CF
J7B CR
PIC-22 JR
ANALOG RANGE VOLTAGES
R91 20.0K 1/8W
R92 20.5K 1/8W
R93 21.0K 1/8W
R94 21.0K 1/8W
R96 210K 1W
ANA GND
RESISTORS = ±1%
S02456
FREQUENCY
DS4 B5092 (NIXIE)
S9
DS5 B5092 (NIXIE)
S10
SOCKET-NIX-112
R65 +300V 82K,1W
R66 +300V 82K,1W
PIC-20
PIC-21
TBZ
FREQ D
ANALOG E
FREQ F
FREQ G
SWEEP H
FREQ J
S3AF10
PIC-23
PIC-24
S3AR7
S3BR7
R59-ARM
S9BR12
START
R13 1.5K CW
R95 1K
C1 30MF 50V
S3AR1
S3AF10
S8
SOCKET = SNKI
K1
R14 18K 2W +300V
P.B KHPITD11
PIA-21
20K/Ω
PIA-15
PIA-3
PIA-20
S7AR6
J6B
PIA-32
PIA-4
S7AF5
20KLIN
LEAD (SHOWN @0°)
R76 5K
R77 60K,1%
PIB-15
10036 R7
PHASE SHIFT
PHASE ANALOG
S6
UNMOD
MOD
PIB-22
S4BR7
R102 10K
R98 15K,CW
R88, 25K
S7AR1
C17 100PF
UNMOD LVL
R81 (SEE)
R97 9.31K 1% 1/4W
R80 1.5K 1% 1/4W
10.3K ±1%
R9A 10K CCW
PIA-6
PIB-12
R82 10K 1% 1/4W
R83 140K 1% 1W
R9B 10K
R84 3.5K
R85 17.5K 1% 5W
R86 610Ω 1%
PIB-10
AMPLITUDE R9-10050 3TURN
X.1 X1.0
S11 PA-2021
CHASSIS (1JTA) PIA
TB2-11
S3AR1
R7A-(E)
TB2-6
R7B-(E)
TB2-1
R9A-SLIP
J5A
J7A
J8A
S7AR1
S6A2
S7AR5
J4A
R7A-SLIP
S7AF4
R8-CCW
R8-CW
J6A
R7B-(E)
R7A-(E)
TB2-7
S3BF10
R8-ARM
S7BF10
J5B
S7AF10
S3BR7
S7AF2
S7AR3
S7AR7
R7B-SLIP
RC1
SIGGND
RC2 90°
LISS°
ANA. SIGGND
+300V
CARR.REF 12°
ANA. -300V
SIG GND
ANA. + 300V
ANA AMPL.
EXT CARR GND
ANA. RANGE
AC LINE
FIL PRI
ANA Ø
FIL PILOT
RCE
RC2
RC1
-300V
MOD AMP
EXT CARR
B+ PRI
B+ PILOT
B+ SEC
26-159-32
CHASSIS (1JTB) PIB
R5A-CCW
S4BF9
S4BR12
ANALOG GND
+300V
J3
ANALOG -300V
J4B
R9B-SLIP
R8SCCW
S1BR1
XF1-1
S1A1
R7C-SLIP
DS1-2
R5C-CW
S4BF10
S4AR1
-300V
S6B1
R8SCW
S2A1
DS2-2
R6TA
S8CF10
SWEEP
PHASE SHIFT
SIGNAL OUTPUT
EXT SIG
YAXIS
REF
S7AR8
PIB-8
PIB-25
S3CR1
PIC-17
R7B-SNS
EXT CARR LVL
R89 1K
PIB-11
S4BR2
PIB-27
ZERO ADJ
R8 10K
PIA-17
PIA-23
PIA-18
S6
PIB-13
S1
FZ (XFZ)
S2
PIB-16
DS1 FIL
PIB-29
DS2 B+
PIB-30
S7
WAVEFORM
PA-2021
SLOPE
PIC-19
PIB-1
PIB-19
PIB-17
PIB-18
DEVIATION 10012 5K 4 GANG
PIB-2
PIB-3
R89-ARM
R103 330
S6B1
CARRIER CPS
S4
PA-2021
500437 (A1) CARRIER PLUG-IN
J2
R5A
R2 24K,1%
R5B
R5C
R3 24K,1%
R5D
R5
R7B-(E)
PIA-1b
PIA-2B
PIA-1Z
PIA-29
PIA-26
PIA-10
R88-CCW
PIA-30
PIA-24
R87 2.5K
J4B
R90 5MEG
S5
PIB-6
C2A-A
PIA-13
PIA-7
(UNMOD)
PIA-19
PIA-8
PIA-9
J3
J4
J5
J6
J7
J8
PIB-8
PIB-25
S3CR1
PIC-17
R7B-SNS
EXTCARR
ZERO
PIA-11
C17 100PF
PIA-1
PIB-31
DS6
DS7
DS8
DS9
S9 S10
FRONT VIEW
S1 PA-2021
S2
S3
S4
S5
S6
S7
S8
S9
S10
DS1
DS2
DS4
DS5
DS6
DS7
DS8
DS9
J3
J4
J5
J6
J7
J8
J4A
J4B
J7B
J8A
J8B
J9
J10
J11
J12
J13
J14
J15
J16
J17
J18
J19
J20
J21
J22
J23
J24
J25
J26
J27
J28
J29
J30
J31
J32
A1
E4
TB3 (TB1&3 NOT SHN)
P1-A,B,C
J8
DS 9
S12
FZ
XF2
R103
C18
K1
SIGNAL GRD.
CASE GRD
ANALOG CONV. GRD
6- GROUND SYMBOLS:
5- CAPACITORS IN MF
4- = COAX RG58A/U
3- = SHIELDED WIRE
2- RESISTORS 5%, 1/2W
1- SYMBOLS ABBREVIATED- PREFIX = A7
NOTES-UNLESS OTHERWISE SPECIFIED:
REMANCO INC.
SANTA MONICA, CALIFORNIA
WIRING DIAGRAM
PANEL
EVODYNE 902D, 902DSG
501530
F
SHEET OF


REVISIONS
B SIZE CHANGED; SW & RANGE CKTS REVISED 11-5-62 GR
C 10-24 MOD. SG WIRING 1-2-63 GR
CHASSIS (1J7C) PIC
RANGE S3 PA-2029
AF AR BF CF CR BR
TB2-2 K1-12 PIA-1 K1-11 TB2-2 K1-10 S9BR12 PIA-22 PIA-27 TB2-9 PIA-32 J7B PIC-22
J8B R90-CCW S9CR12 S10CR11 S3CR7 TB2-3 TB2-4
26-4100-24P
SF-1 SLOPE
ANA RANGE
ANA +300V
ANA FREQ
SWEEP
TB2-10
R60 510
R59 2.5K
R58 32K 5W
-300V
J4A
SWEEP CAPACITORS ±2%
C2A C2B C1BA C1BB C3A C3B C4
R67-10A
#47 PILOT (4)
DS6 DS7 DS8 DS9
SHELL
R64 82K 1W
DS3 B5092 (NIXIE)
-20V -40V -60V -80V
R91 20.0K 1/8W
R92 20.5K 1/8W
R93 21.0K 1/8W
R94 21.0K 1/8W
R96 210K 1/2W
ANALOG RANGE VOLTAGES
ANALOG -300V
ANA GND
RESISTORS ±1%
DS4 DS5 DS3
DS9 DS6 DS8 DS7
S9 S10
FRONT VIEW
REMANCO # 502455
FREQUENCY
DS4 B5092 (NIXIE)
DS5 B5092 (NIXIE)
SOCKET-MSK-112
R65 82K 1W +300V
R66 82K 1W +300V
R12A 22.4K 1W
S9BR12
PIC-20
PIC-21
TBZ
FREQ D
ANALOG E
FREQ F
FREQ G
SWEEP H
FREQ J
PIA-5
S3AF10
PIC-23
PIC-24
PIA-3
PIA-22
S3AR7
S3BR7
R59-ARM
PIA-1
S9BR12
START
R13 1.5K
R95 1K
S3AR7
S3AR1
S3AF10
C1 30MF 50V
SOCKET = 9MK1
K1
P-B KHP17D11 110VDC
R14 18Ω 2W +300V
PIA-21 27° +E
20K/2
SLIP GND
PIA-15
PIA-3
-300V
PIA-20
S7AR6
J6B
PIA-32
PIA-4
S7AF5
CW LEAD (SHOWN @ 0°)
-36V
PIB-15
R76 5K
R77 60K 1% 5W
ANALOG -300V
10036
R7
PHASE SHIFT
PHASE ANALOG
S6 UNMOD MOD
PIB-22
S4BR7
R102 CK
R95 18K 1W
R88 25K
S7AR1
UNMOD LVL
C17 100 PPF
PIA-11
AR
R97 9.31K 1% 1/4W
R80 11.5K 1% 1/4W
10.3K 2.5%
R9A 10K CCW
PIA-6
BR
X-1 X-10
S11 PA-2021
R82 10K 1% 1/4W
R83 66K 1% 1/4W
R9B 10K
R85 17.5K 1% 1/4W
R86 510Ω 1W
AMPL. ANP.
AMPLITUDE R9-10050 3 TURN
ANALOG -300V
PIB-10
S1A1 CARRIER PLUGIN
J2
R5A R5B R5C R5D
AF AR AK BF ER
PIB-1 PIB-9 PIB-17 PIB-18
R5 DEVIATION 10012 5K 4 GANG
PIB-2 PIB-3
R89-ARM
R103 330
S6B
BR1
60 400 EXT
CARRIER CPS PA-2021
S4
R7B-(E) PIA-10 PIA-26 AF
R7B-(+E) PIA-12 PIA-28 R88-CCW AR
PA-29 PIA-30 AR
R67 330K -300V
J4B
PIA-24 BF
K90 SMEG SLOPE
PIC-19
S7 WAVEFORM FA-2021
F1 (XF1) FIL PIB-13 PIB-14 PIB-16 DS1 FIL PIB-29
F2 (XF2) S2 B+ PIB-30 DS2 B+
CHASSIS (1J7A) PIA
TBZ-11 S3AR1 R7A-(E) TB2-5 R7B-(E) TB2-1 R9A-SLIP J8A S7AR1 S6A2 S7AR5 J4A R7A-SLIP S7AF4 R8-CCW R8-CW J6A R7B(+E) R7A(+E) TBZ-7 S3BF10 R8-ARM S7BF10 J5B S7AF10 S3BR7 S7AF2 S7AR3 S7AR7 R7B-SLIP
RC1 SIGGND RC2 (90°) LFO
LF80° ANA SIGGND RC1 OUT AMP ΦUNMOD
YAXIS FUNC 0° MOD AMP SIGAMP SWP ΦAMP SQ INV ZERO ADJ ZERO ADJ CUT AMP LF 0° LF270° RC2 ZERO ADJ SF-1 SLOPE CMOT (SF1) FUNC 180° SWP SIGN SF-1 TRI 180° SF-1 TRI 0° SQ. AMP ΦAMP
SWP & MOD
LFO
26-159-32
CHASSIS (1J7B) PIB
R5A-CCW S4BF3 S4BR12 ANALOG GND +300V J3B ANALOG -300V J4B R9B-SLIP R89CCW S11BR1 XF1-1 S1A1 R7C-SLIP DS1-2 R5C-CCW S4BF10 S4AR1 -300V S6B R89CW S2A1 DS2-2 P67A S3CF10
RC1 GND 180° ANA SIGGND +300V ANA AMP- EXT CARR GND ANA RANGE AC LINE FIL PRI ANA Ø FIL PILOT RC2 RC1 MOD AMP CASE GND EXT CARR B+PRI B+PILOT B+TAP
PWR SUPPLY
CARRIER
26-4100-32P
S5 YAXIS
EXT SIG
C2A-A PIA-7 PIA-13 (UNMOD) PIA-19 PIA-8 PIA-9
J3 REF J4 SWEEP J5 PHASE SHIFT J6 SIGNAL OUTPUT J7 EXT SIG J8 YAXIS
MOD
S7AR8 PIB-8 PIA-25 R7B-SND S3CR1 PIC-17
EXT CARR LVL PIB-11 R89 1K S4BR PIB-27
ZERO ADJ PIA-17 R8 10K PIA-23 PIA-18
A1 TB3 (~B1B3 NOT SHN) P1-A,B,C J8 J1 DS9 S12 S/2 F2 XF2 R103 C18 K1
21,4,6,10,11,15 THRU 57,61,62,63,68 THRU 75,78,79,101
SIGNAL GRD
CASE GRD
ANALOG CONV. GRD
6- GROUND SYMBOLS:
5- CAPACITORS IN MF
4- = COAX RG58A/U
3- = SHIELDED WIRE
2- RESISTORS 5%, 1/2W
1- SYMBOLS ABBREVIATED- PREFIX = 1A7
NOTES: UNLESS OTHERWISE SPECIFIED:
902 DK
REMANCO INC.
SANTA MONICA, CALIFORNIA
WIRING DIAGRAM
PANEL
SERVODYNE 902DK
1A7
SC24-14
C
SCALE
SHEET


REVISIONS
CHASSIS (1J7C) PIC
CHASSIS (1J7A) PIA
CHASSIS (1J7B) PIB
4 GANG, 500K FREQUENCY 10041
RANGE
NON-LINEAR MECH COUPLING
SWEEP
DEVIATION R5 5K, 4-GANG
WAVEFORM PA-2021
CARRIER CPS PA-2021
AMPLITUDE
WIRING DIAGRAM PANEL SERVODYNE 903A
REMANCO INC. SANTA MONICA, CALIFORNIA
502135 C